

Experimental and Research Station,  
Nursery & Market Garden Industries'  
- - Development Society, Limited. - -

Turner's Hill, Cheshunt, Herts.

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Sixteenth Annual Report,  
1930.

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1931.

# Nursery and Market Garden Industries' Development Society, Limited.

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## *Introduction.*

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**I**T is a pleasure to report that the Experimental and Research Station, which was started in 1914, under the auspices of the Nursery and Market Garden Industries' Development Society, continues to develop its activities in all branches. The number of enquiries and problems submitted to the Station increases each year, and already the Laboratories are much over-crowded. Further additions to the Staff are contemplated, and an extension of the present accommodation is urgently required to meet present demands.

In order to qualify for a grant in aid of this extension the sum of £1,900 must be obtained from other sources. £525 was collected by the end of 1930, and it is hoped that those who can will help to further the work by sending donations to the Director.

Membership of the Society, under whose auspices the experiments are conducted, is open to all growers and interested persons, and subscriptions are payable at the rate of two guineas for each acre of glass cultivated by the subscriber ; in return members receive future publications and any advice which is available. Members continue to be enrolled, but many more are needed, both to provide additional funds for research and to obtain complete co-operation in controlling the various pests and diseases common to glasshouse plants. Serious outbreaks over a wide area must be fought by all growers ; isolated attacks on disease are bound to fail.

### Evening Discussions.

The evening lectures for nursery owners and employees, commenced in 1925 at the request of the workers, were continued during the present year, the subjects selected being as follows:—

1929.

Nov. 4th.—Glass. Mr. B. D. Bolas, M.Sc., D.I.C.

Nov. 18th.—(a) Red Spider; (b) The White Fly Parasite. Mr. E. R. Speyer, M.A.

Dec. 2nd.—Soil Analysis and what it means. Dr. O. Owen.

Dec. 16th.—Mankind (Yesterday, To-day, and To-morrow). Dr. W. B. Brierley.

1930.

Jan. 13th.—Old Glass and New. Mr. C. H. Shoults.

Jan. 27th.—The History of Cheshunt. Mr. J. C. Cobley.

Feb. 10th.—Some Garden Plants. Mr. E. A. Bowles, M.V.H.

Feb. 24th.—(a) The History of the Tomato. Mr. W. Corbett. (b) The Importance of Clean Seed. Dr. W. F. Bewley.

Mar. 10th.—Open Night.

Through the kindness of the Lea Valley Growers' Association, to whom we tender our sincere thanks, light refreshments were provided during an interval each evening.

### Current Investigations.

Manurial and crop management trials with tomatoes have been continued. The substitution of wheat straw for stable manure has been tested during the past three years, and in all cases the crop has been improved. It is suggested that substitution can be made at intervals with good results, especially on heavy soils. The application of



wheat straw in addition to stable manure also improved the crop, and growers are asked to conduct small experiments along similar lines to see if these results have a wide application.

A lime experiment was started in two new houses in 1928. The soil on analysis proved to contain only the least traces of lime, and one house was limed, the other being left without lime. In 1928 and 1929 the unlimed house produced a heavier crop than that which received lime. In 1930 two plots in each house were limed and two left untreated. No evidence was obtained to suggest that liming increased the crop.

The watering experiments were continued. Underground watering by means of buried pipes was beneficial, when continued only to the end of May. Later applications by this method caused water-logging of the lower layers of the soil and produced a yellowing of the foliage.

Tomato House 3, where manurial experiments (Series J) had been in progress since 1915, was re-soiled. The old soil was removed to a depth of eighteen inches and replaced with turf soil taken from a meadow near Brimsdown. The house was divided into sixteen plots and used for testing four different forms of nitrogen, namely, sulphate of ammonia, nitrate of soda, and nitrate of lime applied as top dressings, and cyanamide before planting. No difference in crop was noticed in the different plots, but this is not altogether surprising in view of the new soil.

In Tomato House 4 (Series K) six small plots were made at the North end as a permanent demonstration of the effect of (a) withholding manures entirely, and applying (b) complete artificials, (c) complete artificials with stable manure, (d) complete artificials without nitrogen, (e) without phosphate, and (f) without potash. The rest of the house was re-soiled like House 3.

Plots were treated in duplicate with hoot and horn, Peruvian guano, shoddy, dried blood and fish meal. As in House 3, no striking differences were noticed.

In 1929 many new crosses were prepared between Up-to-date, a poor cropping variety highly resistant to Leaf Mould (*Cladosporium fulvum*), and several of the best varieties. The  $F_1$  generation, and in some cases the  $F_2$ , were grown in the Variety House this year. Results suggested that good cropping varieties resistant to Leaf Mould will ultimately be obtained.

The investigations of the temperature requirements of the tomato were continued. The effect of ventilation on air temperature within a glasshouse and the effect of watering on soil temperature has been studied. Further, the rate at which the Station soil cools after steaming has been determined.

The process of warming glasshouse soils by means of buried wires electrically heated has been further examined in relation to different air temperatures. It has been shown that the tomato crop varies distinctly in relation to both soil and air temperatures, maximum crops being obtained at an average night temperature of 67.6°F. with a soil temperature of 68°F., the latter being the highest soil temperature that could be obtained by the heating cables employed. These results in conjunction with those previously reported suggest that the tomato crop would be increased if the average night temperature in commercial houses could be maintained at a higher degree than that usually employed, and that the crop will be further increased when an economic method for heating the soil is devised.

The cucumber experiments were designed to determine the relative value of steam and formaldehyde as a means of sterilising cucumber beds and the soil on which they rest. Formaldehyde raised the yield 12% and steam 36%. Obviously, therefore, the use of steam is to be recommended in preference to formaldehyde. In another series of experiments normal beds of stable manure and loam were compared with those to which straw had been added, and as in previous years the addition of straw proved beneficial.

The Red Spider investigations have been continued, and a study of the life-history of the male mite showed the same number of moults as in the female, so that three stages are passed through before maturity is reached, instead of only two as originally described. The previous error was due to the comparatively short period of the protonymph stage, which occupies a few hours only, and its resemblance to the deutonymph stage.

The testing of substances as fumigants for controlling pests of glasshouse plants has been continued and, in addition, the relative toxicities towards the Red Spider Mite (*Tetranychus telarius*, L.) of the vapours of members of homologous series of compounds have been determined under standardised conditions. The results obtained for the aliphatic monohydric alcohols, their formic esters and the methyl esters of a number of the fatty acids show that the toxicity of the normal compounds increases up to a maximum, and then decreases, on ascending the series, and that the toxicity of isomers decreases with increased branching of the chain. Methyl formate is, however, an exception to the above generalisation.

Experiments have been made to find a substitute for the petroleum-oil emulsion sprays on account of the damage to tomato plants at certain periods of their growth resulting from the use of such emulsions. A sulphonated petroleum derivative giving complete control of the Mite at low concentrations is being tested regarding its action on tomato plants.

#### **White Fly Parasite** (*Encarsia formosa*, Gahan).

The number of applicants supplied with boxes of White Fly Parasites has been 827 as compared with 578 in 1929. The number of boxes dispatched was 3 large, 160 medium and 696 small size, making a total of 859.

The breeding and distribution of the Parasite during the past four years has led to the reduction of the White Fly population in Hertfordshire glasshouses to an almost negligible quantity.



The effect of various sprays and fumigants on Tomato Leaf Mould, *Cladosporium fulvum*, has been studied. On pot plants, control was effected by spraying with either liver of sulphur, salicylanilide, ammonium copper carbonate, ammonium poly-sulphide, lime sulphur or colloidal sulphur when Agral 1 was employed as the spreading agent. They were much less effective with saponin as a spreader, and the increased efficiency seems due to Agral 1. Quinone as a fumigant gave promising results and is being tested further. In fumigations with sulphur, the spores were destroyed on the upper surface of the leaf only.

Experiments also indicate that glasshouses can be freed from infection by fumigation with formaldehyde, by the burning of sulphur, but not by spraying with cresylic acid.

The incidence of Leaf Mould and its relation to environmental conditions has been studied further. Conditions were more favourable to the disease in 1930 than in 1929, and it has been correspondingly more severe. As in 1929, soft plants suffered most.

The optimum and maximum temperatures for spore germination are 72—77°F. and 89°F. respectively; the minimum temperature has not been found but spores germinate at 38°F. The thermal death point is about 115°F. Spores on diseased leaves in glasshouses were not killed by exposure to high temperatures on several consecutive days, and germ tubes, which had been dried for several hours, recommenced growth when placed in water.

The investigations relating to Mosaic Disease have been continued, and successful control of this disease in both cucumbers and tomatoes by the use of clean seed has been confirmed.

The investigation of physical and chemical characteristics by which the infected tissue may be distinguished from normal tissue and the study of the influence of environmental and other conditions on the severity, type,



and development of symptoms *in vivo* have been extended. The physical properties studied include fractional absorption, electrophoresis, absorption spectra in ultra violet light, fluorescence in ultra violet light, phosphorescence in visible spectrum and behaviour on dialysis. The action of the infected sap on chlorophyll *in vitro*\* and some of its enzymic properties have been examined.

The progress and severity of the disease in the living plant has been studied in relation to light of different wave lengths, duration and intensity of light, metabolism† and inoculation methods.

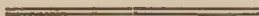
While further work is necessary before definite conclusions can be published, the results already obtained indicate definite progress along certain lines both in the evolution of methods of attack and in obtaining data by these methods.

The manurial experiments in House K had been continued for fourteen years, and when they were discontinued at the end of 1929 it was decided to determine the effects of the respective continuous treatments on the properties and composition of the soil. To this end comprehensive analyses have been made of representative samples of soil from each plot.

In view of the interesting conclusions derived from the analyses of the foliage of tomato plants grown without potash and phosphates respectively, various market garden crops have been grown in these soils and are being analysed to determine how far the conclusions which hold for tomatoes are applicable to these plants.

\* "Nature," January 25th, 1930.

† "Nature," September 27th, 1930.



# DIRECTOR'S REPORT.

## 1. Experimental Results of 1930.

The practice of grading the tomato fruits from the experimental plots, adopted in 1921, was continued during the present season. The fruits were collected in numbered baskets and graded in eight grades as follows:—

- A.—“Pinks” number 5 to 7, and “Pink and White” 8 to 10 to the lb. These are the best quality of fruit in size, shape and colour; “Pinks” being slightly larger than “Pink and Whites.”
- B.—“Whites.” These fruits are of good colour but smaller than “Pink and Whites.”
- C.—“Blues.” This grade consists of fruit of good colour but larger and more irregular in shape than Grade A.
- D.—“Roughs.” Small mis-shapen fruits about the size of cherries.
- E.—Blotchy fruits which ripen irregularly.
- F.—Fruit showing Blossom End Rot.
- G.—Fruits showing the lesions of Stripe Disease.
- H.—Fruits showing “Green Back.”

### 1. Tomatoes.

#### (a) Houses 3 and 4. Fertiliser Experiment.

During the winter of 1929 the soil in House 3 and half of House 4, having been used for fertiliser experiments since 1915, was removed to a depth of 18 inches and replaced with a good turfy loam, the analysis of which was determined by Dr. Owen as follows:—

|                                |     |     |     |     |        |
|--------------------------------|-----|-----|-----|-----|--------|
| Total nitrogen                 | ... | ... | ... | ... | 0.274* |
| „ potash ( $K_2O$ )            | ... | ... | ... | ... | 0.581  |
| „ phosphoric acid ( $P_2O_5$ ) | ... | ... | ... | ... | 0.174  |
| Available potash               | ... | ... | ... | ... | 0.086  |
| „ phosphoric acid              | ... | ... | ... | ... | 0.073  |
| Loss on ignition               | ... | ... | ... | ... | 9.320  |
| Carbonates...                  | ... | ... | ... | ... | Nil.   |

\* Percentage calculated on air dried material.

This analysis is fairly typical of virgin soils in the district, but the potash content is somewhat higher than usual.

The new soil was well flooded with water to consolidate it as much as possible, and given 2 tons finely divided hydrated lime per acre. Stable manure was not applied, the base fertiliser consisting of 4 ozs. bone flour and 4 ozs. sulphate of potash per square yard. House 3 was divided into sixteen plots and used for an experiment with different nitrogenous fertilisers, selecting those that do not persist very long in the soil. Four plots were allocated to each of the following compounds: nitrate of soda, sulphate of ammonia, nitrate of lime and calcium cyanamide. Equivalent amounts of each were given in accordance with their nitrogen content. The cyanamide was applied a month before planting, the remainder being given as top-dressing except for a single half-dressing raked in 14 days before planting. This was done because the soil was new and relatively low in nitrogen.

In House 4, six half-plots ( $12\frac{1}{2}$  ft.  $\times$   $12\frac{1}{2}$  ft.) of the old experimental soils have been arranged at the north end of the house as a permanent demonstration of the effect of the following treatments applied continuously:—

- (1) Complete artificials.
- (2) Complete artificials with stable manure.
- (3) Complete artificials less phosphate.
- (4) Complete artificials less nitrogen.
- (5) Complete artificials less potash.
- (6) No manure.

The south half of this house, re-soiled as House 3, was divided into ten plots and five nitrogenous compounds tested in duplicate, selecting more lasting compounds than those in House 3. They were as follows: dried blood, Peruvian guano, fish manure, hoof and horn and shoddy. The last two were applied before planting.

The variety planted was Ailsa Craig. The looseness of the soil and the relatively large amount of water it was necessary to apply caused an abnormally rank growth at the beginning of the season and poor development of the bottom crop. The top crop was excellent.

The results are given in Tables 1 and 2.

Growers have found in many cases that the crop from virgin soil during the first year is not so good as that of the second season, so that it is not surprising that the crop from

Table 1.  
Nitrogen Experiment.

| Plot. | Compound Tested.     | * Amount<br>per Dressing<br>per Plot of<br>16 sq. yds. | Grade of Fruit: Percentage. |       |       |       |      |    |      |      | Total<br>Lbs.<br>per<br>Plant. | Tons<br>per<br>Acre. | Aver-<br>age<br>Tons<br>per<br>Acre. |
|-------|----------------------|--------------------------------------------------------|-----------------------------|-------|-------|-------|------|----|------|------|--------------------------------|----------------------|--------------------------------------|
|       |                      |                                                        | A.                          | B.    | C.    | D.    | E.   | F. | G.   | H.   |                                |                      |                                      |
| 1     | Sulphate of Ammonium | 1 lb.                                                  | 70.18                       | 17.18 | 3.11  | 8.34  | 1.19 | —  | —    | —    | 4.19                           | 31.84                | 31.79                                |
| 5     |                      | "                                                      | 68.05                       | 19.52 | 4.98  | 7.25  | 0.20 | —  | —    | —    | 4.41                           | 33.51                |                                      |
| 10    |                      | "                                                      | 54.37                       | 19.63 | 11.35 | 13.25 | 0.93 | —  | 0.47 | —    | 4.23                           | 32.15                |                                      |
| 14    |                      | "                                                      | 68.45                       | 20.01 | 1.82  | 8.97  | 0.50 | —  | 0.25 | —    | 3.90                           | 29.64                |                                      |
| 2     | Nitrate of Soda      | 1 lb. 6 ozs.                                           | 66.84                       | 21.41 | 2.82  | 8.43  | 0.50 | —  | —    | —    | 3.92                           | 29.79                | 32.28                                |
| 6     |                      | "                                                      | 67.77                       | 17.15 | 6.91  | 7.95  | 0.22 | —  | —    | —    | 4.78                           | 36.33                |                                      |
| 9     |                      | "                                                      | 54.78                       | 22.60 | 6.14  | 13.52 | 2.46 | —  | 0.25 | 0.25 | 4.07                           | 30.93                |                                      |
| 13    |                      | "                                                      | 68.48                       | 19.43 | 2.84  | 8.55  | 0.24 | —  | 0.46 | —    | 4.22                           | 32.07                |                                      |
| 4     | Cyanamide            | 1 lb. 4 ozs.                                           | 67.76                       | 19.39 | 3.72  | 8.88  | 0.25 | —  | —    | —    | 4.28                           | 32.53                | 33.67                                |
| 8     |                      | "                                                      | 63.72                       | 18.42 | 6.86  | 10.40 | 0.39 | —  | 0.21 | —    | 5.10                           | 38.76                |                                      |
| 11    |                      | "                                                      | 54.68                       | 20.54 | 6.21  | 12.41 | 0.94 | —  | 0.22 | —    | 4.19                           | 31.84                |                                      |
| 15    |                      | "                                                      | 71.35                       | 20.22 | 1.43  | 6.50  | —    | —  | 0.25 | 0.25 | 4.15                           | 31.54                |                                      |
| 3     | Nitrate of Lime      | 2 lbs.                                                 | 65.33                       | 21.08 | 5.15  | 7.73  | 0.71 | —  | —    | —    | 4.27                           | 32.45                | 34.77                                |
| 7     |                      | "                                                      | 70.44                       | 17.12 | 5.05  | 7.01  | 0.19 | —  | 0.19 | —    | 5.55                           | 42.18                |                                      |
| 12    |                      | "                                                      | 64.37                       | 21.85 | 3.69  | 9.35  | 0.48 | —  | 0.26 | —    | 4.07                           | 30.93                |                                      |
| 16    |                      | "                                                      | 73.87                       | 16.15 | 2.51  | 6.37  | 0.89 | —  | 0.21 | —    | 4.40                           | 33.44                |                                      |

\* Six dressings given except in the case of cyanamide, which was given only before planting.



Table 2.  
Nitrogen Experiment.

| Plot.   | Compound Tested.        | Amount<br>per Dressing<br>per Plot of<br>16 sq. yds. | Grade of Fruit : Percentage. |                |               |               |              |        |              | Total<br>Lbs.<br>per<br>Plant. | Tons<br>per<br>Acre. | Average<br>Tons<br>per<br>Acre. |
|---------|-------------------------|------------------------------------------------------|------------------------------|----------------|---------------|---------------|--------------|--------|--------------|--------------------------------|----------------------|---------------------------------|
|         |                         |                                                      | A                            | B.             | C.            | D.            | E.           | F.     | G.           | H.                             |                      |                                 |
| 4<br>10 | Hoof and Horn<br>" " "  | 14 lbs.<br>"                                         | 72.24<br>71.90               | 15.07<br>15.92 | 3.82<br>5.09  | 5.52<br>4.86  | 1.15<br>1.77 | —<br>— | 0.20<br>0.23 | —<br>0.23                      | 39.82<br>34.35       | 37.09                           |
| 5<br>9  | Peruvian Guano<br>" " " | 1 lb. 10 ozs.<br>"                                   | 68.87<br>73.99               | 17.12<br>14.28 | 5.91<br>5.52  | 6.78<br>4.85  | 0.66<br>1.15 | —<br>— | 0.66<br>0.21 | —<br>—                         | 34.65<br>32.98       | 33.87                           |
| 6<br>13 | Shoddy<br>" " "         | —<br>—                                               | 70.58<br>70.15               | 14.27<br>15.25 | 7.58<br>7.20  | 6.49<br>5.88  | 0.65<br>0.86 | —<br>— | 0.43<br>0.66 | —<br>—                         | 35.11<br>34.88       | 35.00                           |
| 7<br>12 | Dried Blood<br>" " "    | 1 lb. 12 ozs.<br>"                                   | 68.61<br>64.84               | 14.20<br>19.62 | 8.78<br>6.45  | 6.74<br>7.90  | 1.11<br>0.47 | —<br>— | 0.56<br>0.72 | —<br>—                         | 40.66<br>31.77       | 36.22                           |
| 8<br>11 | Fish Manure<br>" " "    | 2 lbs. 8 ozs.<br>"                                   | 60.09<br>65.86               | 15.23<br>17.21 | 10.89<br>9.25 | 12.21<br>6.78 | 1.13<br>0.45 | —<br>— | 0.45<br>0.45 | —<br>—                         | 33.51<br>33.59       | 33.55                           |

Table 3.

| Plot. | Treatment.                                     | Grade of Fruit : Percentage. |      |       |      |      |      |      |      | Total<br>Lbs.<br>per<br>Plant. | Total<br>Tons<br>per<br>Acre. | Average<br>Tons<br>per<br>Acre. |
|-------|------------------------------------------------|------------------------------|------|-------|------|------|------|------|------|--------------------------------|-------------------------------|---------------------------------|
|       |                                                | A.                           | B.   | C.    | D.   | E.   | F.   | G.   | H.   |                                |                               |                                 |
| 1     | Control : Normal Watering                      | 33.20                        | 5.92 | 48.50 | 4.46 | 3.71 | 0.25 | 3.71 | 0.25 | 3.86                           | 29.33                         | 31.00                           |
| 6     | “ “ “                                          | 38.37                        | 6.00 | 44.43 | 3.50 | 3.50 | 0.24 | 3.72 | 0.24 | 4.30                           | 32.68                         |                                 |
| 3     | Underground Watering: Pipes 15" deep           | 31.56                        | 6.85 | 57.80 | 2.90 | 0.45 | —    | 0.50 | —    | 4.51                           | 31.31                         | 33.21                           |
| 8     | “ “ “                                          | 29.89                        | 5.20 | 53.21 | 3.91 | 2.82 | —    | 4.76 | 0.21 | 4.62                           | 35.11                         |                                 |
| 5a    | “ “ “                                          | 42.55                        | 9.14 | 41.40 | 3.24 | 0.02 | —    | 3.44 | 0.01 | 5.25                           | 39.92                         | 38.00                           |
| 4     | Flooded Heavily in Winter                      | 39.06                        | 5.78 | 46.96 | 3.09 | 3.82 | 0.22 | 1.85 | 0.22 | 4.72                           | 35.88                         |                                 |
| 7     | “ “ “ “ “ “                                    | 32.59                        | 5.49 | 50.55 | 3.98 | 3.41 | 0.38 | 3.60 | —    | 5.28                           | 40.12                         | 30.61                           |
| 2     | Two " " " " " " Pipes; for Winter Flooding ... | 34.15                        | 6.46 | 48.70 | 3.46 | 3.98 | 0.26 | 2.73 | 0.26 | 4.02                           | 30.61                         |                                 |

the above houses did not come up to expectation this year. While the figures do not show any marked difference between the treatments, they suggest that the organic forms of nitrogenous compounds such as hoof and horn, may be more suitable for the tomato than inorganic forms such as sulphate of ammonia. The experiments will be continued and more regular results may be expected next year.

#### (b) Watering experiments.

These experiments were continued with slight variations. Four plots remained unaltered, namely, the controls, 1 and 6, and 3 and 8, adapted for underground watering for 1928. In addition two plots, 4 and 7, were heavily flooded in the winter, water being given in three applications at the rate of 48,000 gallons per acre. Two rows of 2 inch drain tiles were buried 15 inches below the surface in Plot 2, for the purpose of winter flooding. Each row was conducted to the surface by a 4 inch drain pipe, water being applied to the subsoil at the rate of 30,000 gallons per acre through a hose placed in the top of this pipe.

In another plot, 5a, the underground watering system of Plots 3 and 8 was repeated, but the pipes were laid only 12 inches deep. The results are given in Table 3, and a comparison with those of the two previous years in Table 4.

**Table 4.**

| Treatment.                                   | Average Yield in Tons per Acre. |       |       |
|----------------------------------------------|---------------------------------|-------|-------|
|                                              | 1928.                           | 1929. | 1930. |
| Control: Normal Watering ... ..              | 30.11                           | 31.75 | 31.00 |
| Winter Flooding (48,000 galls. per acre) ... | —                               | —     | 38.00 |
| Underground Watering: (a) Pipes 15" deep...  | 31.71                           | 36.92 | 33.21 |
| "      "      (b) Pipes 12" deep...          | —                               | —     | 39.92 |
| Planted in Trenches ... ..                   | 31.50                           | 34.70 | —     |

Underground watering is an advantage during the early part of the season, for it provides a slightly earlier crop and also retards the appearance of Tomato Leaf Mould. Except in 1929, the crop increase is only slight.

Under conditions prevailing in this country, it is doubtful if the method will ever come into general application, for unless the soil is sufficiently heavy to retain the water, the amount used is greatly in excess of normal requirements; if too heavy the subsoil becomes waterlogged, with consequent injury to the crop.

It will be noticed, however, that placing the pipes nearer to the surface was a considerable improvement; the experiment will be repeated later.

The striking result of the current experiment is the increase in crop following heavy winter flooding. Reduced yields have frequently been traced on commercial nurseries to a dry subsoil, and the above results provide useful confirmation.

### **(c) "Stopping" versus "non-stopping."**

Tomato House 1 was employed to test the effect of different methods of "stopping" the tomato plant, variety E.S.1 being grown and the house divided into eight equal plots. The plants in two plots were allowed to grow without any attempt at "stopping"; in two they were "stopped" at the third truss only, in two others at the third truss and later at every second truss, while in the remaining two plots the plants were "stopped" at the fifth truss only. The results are given in Table 5.

As in previous years the heaviest crop was obtained when the plants were grown on, without "stopping." A relatively high yield was obtained where the plants were stopped at the third and each succeeding second truss, but this result is rendered less significant by the variation between the two plots, 2 and 5.

### **(d) Variety trials.**

The Variety House was used to cultivate the  $F_1$  generations of a number of crosses prepared in 1929, when selected varieties were crossed with E.S.1 and Up-to-date. The Up-to-date series terminated in July when seed was taken, the  $F_2$  generation being planted in July. The crop records from these plants were not taken.

Leaf Mould (*Cladosporium fulvum*) was not serious during the early part of the year in this house, and no marked resistance in the  $F_1$  generations was noted. The second crop, however, was badly attacked and it was possible to select individual plants which combined disease resistance with reasonable cropping capacity. Seed from these plants was saved for cultivation during 1931.



Table 5.

| Plot. | Treatment.                               | Grade of Fruit: Percentage. |       |      |      |      |      |      |      | Total<br>Lbs<br>per<br>Plant. | Total<br>Tons<br>per<br>Acre. | Average<br>Tons<br>per<br>Acre |
|-------|------------------------------------------|-----------------------------|-------|------|------|------|------|------|------|-------------------------------|-------------------------------|--------------------------------|
|       |                                          | A.                          | B.    | C.   | D.   | E.   | F.   | G.   | H.   |                               |                               |                                |
| 1     | Unstopped                                | 75.60                       | 16.76 | 0.60 | 2.59 | 0.99 | 0.16 | 3.34 | —    | 5.02                          | 38.06                         | 37.10                          |
| 6     | Unstopped                                | 69.30                       | 23.20 | 0.13 | 3.40 | 0.83 | 0.20 | 2.94 | —    | 4.89                          | 36.14                         |                                |
| 4     | Stopped at 3rd Truss only                | 71.41                       | 18.71 | 1.08 | 3.74 | 1.08 | —    | 3.98 | —    | 4.27                          | 32.61                         | 33.29                          |
| 7     | Stopped at 3rd Truss only                | 76.80                       | 16.80 | 0.88 | 2.78 | 1.12 | —    | 1.62 | —    | 4.47                          | 33.96                         |                                |
| 2     | Stopped at 3rd Truss and every 2 Trusses | 74.90                       | 13.81 | 1.16 | 2.08 | 1.85 | 0.25 | 0.70 | 0.25 | 4.30                          | 32.68                         | 36.07                          |
| 5     | Stopped at 3rd Truss and every 2 Trusses | 78.22                       | 15.58 | 1.58 | 2.46 | 1.58 | —    | 1.58 | —    | 5.19                          | 39.39                         |                                |
| 3     | Stopped at 5th Truss only                | 75.60                       | 16.80 | 1.10 | 2.70 | 1.10 | 0.20 | 2.50 | —    | 4.40                          | 33.44                         | 34.25                          |
| 8     | Stopped at 5th Truss only                | 73.23                       | 17.60 | 1.10 | 1.94 | 2.17 | 0.66 | 3.30 | —    | 4.61                          | 35.05                         |                                |

Table 6.

| Variety.                             | Grade of Fruit: Percentage. |       |       |      |      |      | Total<br>Lbs<br>per<br>Plant. | Total<br>Tons<br>per<br>Acre. |
|--------------------------------------|-----------------------------|-------|-------|------|------|------|-------------------------------|-------------------------------|
|                                      | A.                          | B.    | C.    | D.   | E.   | F.   | G.                            |                               |
| Tuckswood $\times$ E.S.1 ( $F_1$ )   | 72.64                       | 21.36 | 0.65  | 4.28 | 0.23 | —    | 0.84                          | 35.57                         |
| E.S.1 $\times$ E.S.3 ( $F_3$ )       | 77.54                       | 16.56 | 2.51  | 2.71 | —    | —    | 0.68                          | 33.52                         |
| Buckley $\times$ E.S.1 ( $F_1$ )...  | 78.03                       | 12.77 | 5.55  | 2.67 | 0.73 | —    | 0.25                          | 31.55                         |
| Riverside $\times$ E.S.1 ( $F_1$ )   | 72.63                       | 20.73 | 2.21  | 3.70 | —    | 0.25 | 0.48                          | 30.78                         |
| Riverside Favourite                  | 66.51                       | 7.70  | 22.82 | 2.22 | 0.49 | —    | 0.26                          | 30.63                         |
| Ailsa Craig $\times$ E.S.1 ( $F_1$ ) | 62.68                       | 20.88 | 7.47  | 6.97 | 0.49 | —    | 1.51                          | 30.56                         |



All the individuals of the  $F_2$  generation of crosses between Up-to-date and Water Baby, Buckley, and E.S.2 proved very susceptible. Resistant individuals occurred in the crosses between Up-to-date and Riverside Favourite, Tuckswood, Maincrop, Manx Marvel, and an unnamed seedling termed No. 1.

Crop records of the plants grown to the end of the season are given in Table 6; it will be seen that the  $F_1$  generation of the E.S.1 and Tuckswood cross provided the highest yield. Moreover both habit and type of fruit were excellent.

**(e) Investigations concerning the reduction in yield of the tomato crop by continuous cultivation in the same soil.**

The experiments in this section have been concerned mainly with the question as to whether the soil can be improved by applications of plain wheat straw both alone or in addition to stable manure. The results are given in Table 7. It will be seen that the average yield from five plots receiving normal treatment with 15 tons of stable manure was 30·9 tons per acre, while that from five plots in which straw was used instead of stable manure was 34·8 tons per acre. The average yield from four plots receiving both stable manure and straw was 34·1 tons per acre.

Similar results have been obtained in previous years, and together with the trials on commercial nurseries they indicate that the physical condition of tomato soils is a most important factor. Heavy and moderately heavy soils can be improved by applications of straw, which not only produces an open, well aerated condition but acts as a source of energy to the organisms in the soil. Growers are advised to test the effect of adding straw to their soil in amounts between 5 and 10 tons per acre.

In 1928 experiments were started to determine the effect on the tomato of a previous crop of tulips grown between October and February. The bulbs were planted in rows, space being left for tomatoes in case the tulip flowers had not been marketed by the middle of February. No heat was applied until a fortnight before setting out the tomatoes and usually the flowers were picked between 14-21 days after the tomatoes were planted. The cost of the bulbs and their cultivation was approximately one penny each, and the flowers were sold at an average price of two shillings per dozen.

In the experiments, some plots were sterilised with formaldehyde, and planted seven days later with tulips, others were sterilised but not planted with tulips, while in others tulips were planted in unsterilised soil,

It was anticipated at the beginning that the soil and tomato crop would be improved by the tulip roots, which were allowed to decay in the soil, but the results given in Table 8 do not confirm this. Where any increase occurs it is mainly due to treatment with formaldehyde.

Table 8.

| House. | Plot. | Treatment.                                         | Crop Yield in Tons per Acre. |       |       | Average of 2 or 3 Years. |
|--------|-------|----------------------------------------------------|------------------------------|-------|-------|--------------------------|
|        |       |                                                    | 1928.                        | 1929. | 1930. |                          |
| 7      | 5     | Soil Sterilised with Formaldehyde ..               | —                            | 44.99 | 37.09 | 41.04                    |
| 8      | 5     | Normal Soil: Tulips Planted ...                    | —                            | 43.55 | 35.04 | 39.30                    |
| 8      | 4     | Soil Sterilised with Formaldehyde: Tulips Planted. | 44.69                        | 44.99 | 33.60 | 41.09                    |
| 9      | 4     | Soil Sterilised with Formaldehyde: Tulips Planted. | —                            | 48.56 | 37.08 | 42.82                    |
|        |       | Average of Controls (4 Plots) ...                  | 37.50                        | 46.01 | 30.90 | 38.14                    |

#### (f) Lime.

The liming experiment in Houses 11 and 12 has been continued. At the beginning of the experiment in 1928 the soil was new, and contained, on analysis, very slight traces of carbonates.

House 11, unlimed in 1928 and 1929, gave 52.7 and 46.2 tons per acre respectively. House 12, treated with 2 tons caustic lime per acre, gave 40.7 and 36.3 tons per acre respectively during the same two years. This suggested that the addition of lime actually reduced the yield of the tomato during the first two years' cultivation on new soil. In 1930, two plots in each house were limed, and two left untreated. E.S.1 was grown in House 11, and E.S.3, which requires further selection, gave a comparatively small crop in House 12. While no comparison can be drawn between the two houses, it will be seen that in House 11 liming in the third year did not affect the crop materially, while in House 12 the omission of lime in the third year after two previous limings gave a slight increase. The results suggest that liming experiments on a large scale are necessary.



Table 9.

| House. | Plot. | Treatment. |         |         | Grade of Fruit: Percentage. |       |       |      |      |    |      | Total<br>Lbs.<br>per<br>Plant. | Total<br>Tons<br>per<br>Acre. | Average<br>Tons<br>per<br>Acre. |
|--------|-------|------------|---------|---------|-----------------------------|-------|-------|------|------|----|------|--------------------------------|-------------------------------|---------------------------------|
|        |       | 1928.      | 1929.   | 1930.   | A.                          | B.    | C.    | D.   | E.   | F. | G.   | H.                             |                               |                                 |
| 11     | 1     | No Lime    | No Lime | Lime    | 83.49                       | 11.26 | 1.13  | 2.81 | 0.37 | —  | 0.94 | —                              | 40.51                         | 41.54                           |
| —      | 3     | "          | "       | "       | 82.82                       | 9.81  | 2.14  | 3.40 | 1.08 | —  | 0.75 | —                              | 42.56                         |                                 |
| —      | 2     | "          | "       | No Lime | 83.41                       | 9.31  | 1.41  | 4.46 | 0.40 | —  | 1.01 | —                              | 37.46                         | 40.43                           |
| —      | 4     | "          | "       | "       | 83.89                       | 10.51 | 1.75  | 2.97 | 0.53 | —  | 0.35 | —                              | 43.39                         |                                 |
| 12     | 1     | Lime       | Lime    | Lime    | 65.39                       | 7.23  | 22.79 | 2.15 | 0.82 | —  | 1.62 | —                              | 28.35                         | 25.43                           |
| —      | 3     | "          | "       | "       | 80.41                       | 7.42  | 7.42  | 2.05 | 0.65 | —  | 2.05 | —                              | 22.51                         |                                 |
| —      | 2     | Lime       | Lime    | No Lime | 82.00                       | 6.32  | 7.50  | 2.69 | 0.59 | —  | 0.90 | —                              | 25.31                         | 27.48                           |
| —      | 4     | "          | "       | "       | 55.63                       | 7.20  | 30.26 | 3.34 | 2.29 | —  | 1.28 | —                              | 29.64                         |                                 |

## 2. Cucumber Experiments.

The cucumber experiments conducted during 1930 were arranged with the object of checking previous results which had been obtained from small experiments spread over a number of years.

### (a) Steam versus Formaldehyde.

Past experiments with chemical sterilisers have not improved the crop to the same extent as steam, but probably the best of them is formaldehyde. Accordingly for 1930, the old beds were dug into the base to ensure a suitable degree of contamination, and four plots were treated with steam and four with formaldehyde. When steaming, the soil was kept at a temperature of  $212^{\circ}\text{F}$ . for 30 minutes and in the case of formaldehyde one gallon of the 40% material, diluted with 49 gallons of water, was applied to 18 square yards, the soil being then turned over one spit deep. The results in Table 1 show that steaming provided an average yield of 1.96 flats per foot, and formaldehyde 1.61 flats per foot, the yield from the untreated control being 1.44 flats per foot. This represents an increased yield of 11.8% from the formaldehyde treatment and 36.1% as the result of steaming.

It is clear that steaming provides the most satisfactory method of cleaning the soil for cucumber cultivation.

### (b) Improvement of the beds by the addition of straw.

It has been found in the past that the health and crop producing power of cucumber plants is affected adversely when the beds are hard and tight. Any method of opening the bed to improve the drainage and aeration has improved the crop. In the present experiment the base was steamed during the winter. In four plots normal beds of two parts baked soil and one part stable manure were used: in four others the beds consisted of two parts baked soil, one part stable manure and one part wheat straw cut in pieces 2 feet long, while two were prepared of two parts baked soil, and two parts straw. In the last case the only stable manure given to the plants was in the form of two top-dressings. The normal beds gave an average crop of 1.80 flats per foot, those receiving straw in addition to stable manure 1.86 flats per foot, and those made up of soil and straw only produced 1.95 flats per foot.

It will be seen that no increase resulted from the addition of straw to the normal bed, and in view of previous results it would seem that the type of soil used this year remained

Variety: Butcher's Disease Resister.

Table I.

| Plot. | Treatment during 1930.        |                                                                   | Crop yield in pounds per Plant. |        |       |       |       |      |        | Total.         |                 |
|-------|-------------------------------|-------------------------------------------------------------------|---------------------------------|--------|-------|-------|-------|------|--------|----------------|-----------------|
|       | Base.                         | Bed.                                                              | March.                          | April. | May.  | June. | July. | Aug. | Total. | Tons per Acre. | Flats per Foot. |
| C1    | Steamed.                      | Heather Peat: Baked Soil: Artificial.                             | 2.88                            | 13.72  | 8.86  | 7.00  | 6.76  | 3.14 | 42.36  | 63.54          | 1.31            |
| C3    | "                             | "                                                                 | 2.40                            | 12.34  | 10.26 | 9.65  | 8.61  | 4.00 | 47.23  | 70.85          | 1.45            |
| C2    | "                             | Stable Manure: Baked Soil: Artificial.                            | 1.60                            | 12.87  | 11.56 | 10.50 | 9.67  | 6.92 | 53.12  | 79.68          | 1.64            |
| C4    | "                             | "                                                                 | 4.00                            | 12.57  | 10.67 | 10.64 | 10.05 | 6.10 | 54.03  | 81.05          | 1.67            |
| D2    | "                             | 1929 Beds Spread and Steamed                                      | 5.95                            | 13.44  | 11.89 | 11.97 | 14.93 | 9.30 | 67.48  | 101.22         | 2.10            |
| D4    | "                             | "                                                                 | 5.16                            | 12.84  | 18.21 | 11.59 | 13.04 | 8.31 | 69.15  | 103.73         | 2.12            |
| D6    | "                             | "                                                                 | 5.95                            | 14.95  | 10.78 | 12.39 | 12.69 | 6.00 | 62.76  | 94.14          | 1.93            |
| E4    | "                             | "                                                                 | 5.37                            | 12.50  | 10.45 | 9.18  | 11.28 | 6.22 | 55.00  | 82.50          | 1.69            |
| D3    | —                             | 1929 Beds Spread and Treated with Formaldehyde.                   | 4.05                            | 12.41  | 10.88 | 9.55  | 11.43 | 6.44 | 54.76  | 82.14          | 1.68            |
| D5    | —                             | "                                                                 | 5.76                            | 10.92  | 10.66 | 8.47  | 10.71 | 4.02 | 50.54  | 75.81          | 1.56            |
| E3    | —                             | "                                                                 | 5.93                            | 11.34  | 10.77 | 9.88  | 10.47 | 6.78 | 55.00  | 82.50          | 1.69            |
| E7    | —                             | "                                                                 | 6.92                            | 12.09  | 8.33  | 8.74  | 9.90  | 3.46 | 49.44  | 74.16          | 1.52            |
| E5    | —                             | Controls: 1929 Beds Spread ...                                    | 4.33                            | 10.80  | 9.95  | 8.22  | 9.39  | 3.99 | 46.68  | 70.02          | 1.44            |
| F1    | 1929 beds spread and steamed. | Normal Bed ...                                                    | 6.31                            | 12.91  | 11.40 | 10.40 | 12.91 | 8.27 | 62.30  | 93.45          | 1.92            |
| F3    | "                             | "                                                                 | 3.76                            | 13.23  | 10.82 | 10.87 | 10.14 | 5.39 | 54.21  | 81.32          | 1.67            |
| F5    | "                             | "                                                                 | 3.66                            | 14.10  | 11.32 | 10.28 | 12.45 | 6.80 | 58.61  | 87.92          | 1.81            |
| F9    | "                             | "                                                                 | 4.44                            | 13.29  | 11.91 | 8.83  | 12.09 | 8.28 | 58.85  | 88.28          | 1.81            |
| F2    | "                             | Normal Bed with Straw ...                                         | 6.10                            | 14.39  | 10.89 | 12.17 | 11.46 | 8.52 | 63.53  | 95.30          | 1.97            |
| F6    | "                             | "                                                                 | 2.51                            | 14.28  | 11.25 | 11.71 | 11.64 | 8.22 | 59.61  | 89.42          | 1.84            |
| F8    | "                             | "                                                                 | 4.77                            | 14.14  | 11.28 | 8.78  | 12.55 | 7.85 | 59.37  | 89.06          | 1.82            |
| F10   | "                             | "                                                                 | 6.39                            | 13.40  | 10.23 | 10.72 | 10.02 | 7.05 | 57.81  | 86.72          | 1.78            |
| F4    | "                             | Baked Soil and Straw (no Stable Manure except two Top-dressings). | 4.24                            | 15.39  | 12.00 | 10.97 | 12.74 | 7.39 | 62.73  | 94.00          | 1.93            |
| F7    | "                             | "                                                                 | 3.76                            | 15.90  | 12.96 | 10.26 | 13.48 | 7.15 | 63.51  | 95.27          | 1.97            |

sufficiently open during the season, and was not improved by further opening material. The experiment will be continued in 1931, with imported soil of a heavy nature.

**(c) The addition of heather peat to cucumber beds.**

The peat experiment of 1929 was continued, substituting a heather peat for the previous *Sphagnum* peat. The material contained decayed heather roots in addition to a good deal of fine black organic material. It will be seen that the crop was reduced appreciably in the beds receiving this material.

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## 2. Mycological Investigations.

The following diseases not previously reported have been recorded during the year:—

| Host.              | Disease.                    | Cause.                         |
|--------------------|-----------------------------|--------------------------------|
| Bean ... ..        | Foot rot ... ..             | <i>Botrytis cinerea</i>        |
| Begonia ... ..     | Rot of young plants ... ..  | Bacterial                      |
| Cauliflower ... .. | Damping off ... ..          | <i>Rhizoctonia solani</i>      |
| Dianthus ... ..    | Dieback ... ..              | <i>Dinematosporium dianthi</i> |
| Fig ... ..         | Fruit rot ... ..            | <i>Botrytis cinerea</i>        |
| Geranium ... ..    | Leaf spot ... ..            | <i>Botrytis cinerea</i>        |
| Gerbera ... ..     | Crown and root rot ... ..   | <i>Verticillium sp.</i>        |
| Iris ... ..        | Root rot ... ..             | <i>Rhizoctonia sp.</i>         |
| Iris ... ..        | Leaf spot ... ..            | <i>Macrosporium sp.</i>        |
| Lettuce... ..      | Downy mildew ... ..         | <i>Bremia lactucae</i>         |
| Lettuce... ..      | Leaf spot ... ..            | Bacterial                      |
| Marguerite ... ..  | Leaf spot ... ..            | <i>Cladosporium sp.</i>        |
| Melon ... ..       | Damping off of fruit ... .. | Physiological                  |
| Narcissus ... ..   | Failure of bloom... ..      | Physiological                  |
| Onion ... ..       | Bulb rot ... ..             | <i>Sclerotium cepivorum</i>    |
| Pyrethrum ... ..   | Death of foliage ... ..     | <i>Rhizoctonia sp</i>          |
| Violet ... ..      | Root rot ... ..             | Nematode                       |

### 1. Further studies of the micro-flora of certain tomato soils.

By P. H. WILLIAMS.

During 1929, counts were made of the numbers of bacteria, actinomyces and fungi in certain plots in House 4 (Series K). An account appeared in the Fifteenth Annual Report (1929). In the present year, further work has been done to amplify and confirm the results obtained. In addition, certain points of interest have been investigated in detail.

In November, 1929, the soil in the house was exchanged for virgin turf. A part of the original soil was kept and used to make demonstration plots at the north end of the house. Care was taken not to mix the soils from different plots so that the same soils were available for study as last year.

As a result of being moved, the different layers in the soil were mixed, and no doubt this caused a certain amount of disturbance in the distribution of bacteria. Accordingly, sampling did not commence until January, 1930, thus allowing time for the soil to settle and for conditions to become normal; samples were then taken each week until January, 1931. The technique of sampling and counting was the same as in 1929. Counts of fungi were omitted.



The plots selected for study were as follows:—

2. No manure.
4. Complete artificials and stable manure.
5. Complete artificials.
- V. Virgin turf receiving a dressing of hoof and horn.

In the case of Plot 4, the stable manure was omitted in the spring of 1930. Before planting lettuce, in the autumn, however, all the plots were manured and Plot 4 then received its usual dressing.

#### **Numbers of bacteria.**

The results are shown in Table 1 and also in Fig. 1. The numbers in the three original plots tend to rise and fall together, giving throughout the season a series of sharp peaks. The high values last only for a short time. It is difficult to compare the results with those obtained in 1929, since the number of records in that year was much smaller. There seems to be definite evidence for somewhat high values during February and March and again in the early summer, May to July.

#### **Effect of hoof and horn.**

The virgin soil stands by itself as the result of the dressing of nitrogenous manure it received. In the spring, the effect was first seen in a count made ten days after the application of the manure. Up to that time, the variations in number had corresponded to those found in the other plots. The effect of the manure lasted until July. In the autumn, a week sufficed to show the effect, and it was considerably greater. As will be seen from Table 2 a maximum of 1,259 million bacteria per gramme of dry soil was recorded. That these figures are not the result of the actual addition of large numbers of bacteria in the manure is shown by the fact that only 226,900 bacteria per gramme were present in the original sample.

#### **Effect of stable manure.**

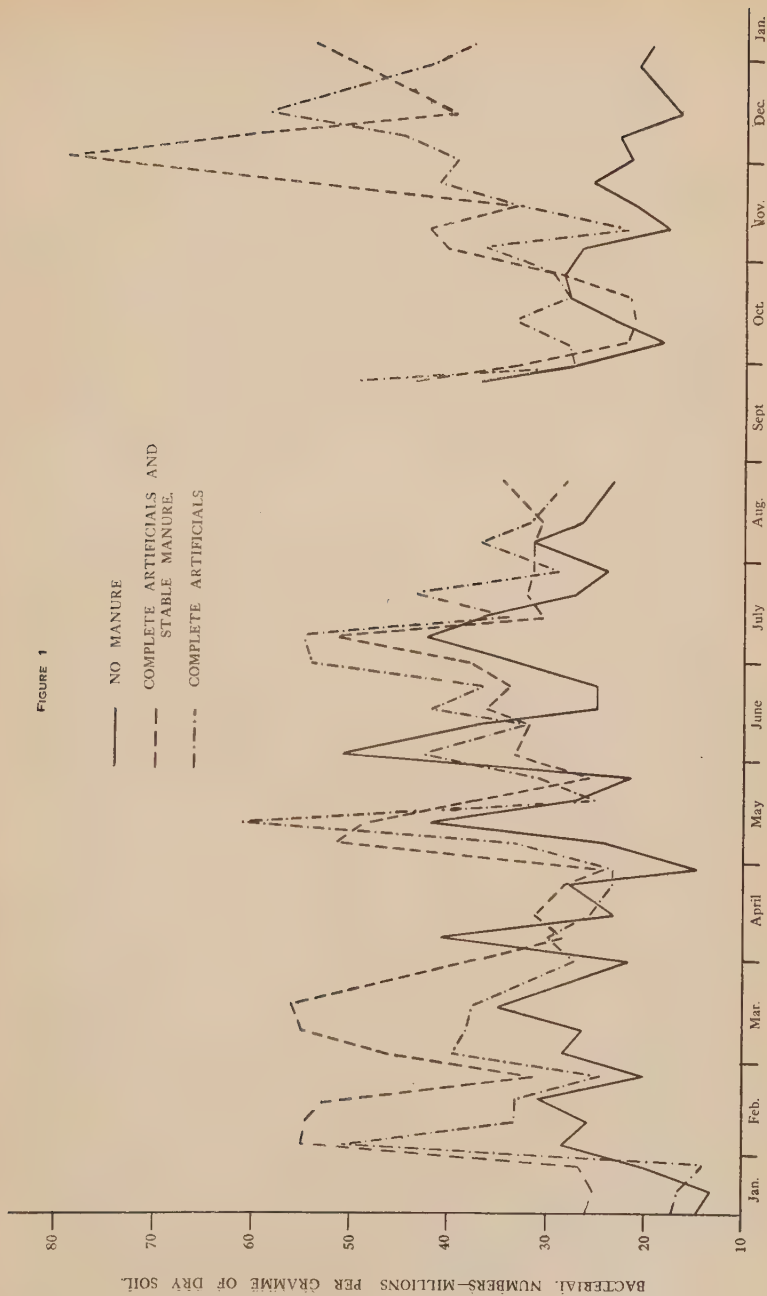
In 1929, a maximum of 78·20 million bacteria was recorded in the plot receiving complete artificials and stable manure, while on the same date only 30·27 million were present in the plot receiving complete artificials only. As mentioned above, stable manure was omitted in the spring of 1930. The corresponding figures were 56·15 and 37·50 millions in the two plots. In the autumn, however, addition of stable manure resulted in a maximum of 79·21 million against 39·45 in the plot receiving complete artificials. From the effect of the hoof and horn it may be concluded that the increase in

Table 1.

Number of Bacteria (millions per gramme of oven dry soil).

| Date.    | Plot 2. | Plot 4. | Plot 5. | Plot V. |
|----------|---------|---------|---------|---------|
| 14/1/30  | 14.61   | 24.91   | 17.44   | 15.40   |
| 21/1/30  | 13.14   | 23.15   | 16.48   | 15.20   |
| 28/1/30  | 20.04   | 26.51   | 14.23   | 12.33   |
| 4/2/30   | 28.31   | 55.01   | 50.58   | 44.58   |
| 11/2/30  | 25.77   | 54.46   | 33.24   | 43.88   |
| 18/2/30  | 30.73   | 52.74   | 33.16   | 30.07   |
| 25/2/30  | 20.06   | 31.25   | 24.40   | 335.70  |
| 4/3/30   | 28.35   | 46.44   | 39.67   | 252.00  |
| 11/3/30  | 26.41   | 55.06   | 38.20   | 164.80  |
| 18/3/30  | 35.05   | 56.15   | 37.50   | 428.70  |
| 1/4/30   | 21.66   | 37.46   | 27.17   | 335.30  |
| 8/4/30   | 40.70   | 28.31   | 29.90   | 87.84   |
| 15/4/30  | 23.10   | 31.30   | 25.57   | 101.60  |
| 24/4/30  | 27.67   | 28.25   | 23.36   | 88.69   |
| 29/4/30  | 14.58   | 23.97   | 23.27   | 80.54   |
| 7/5/30   | 24.22   | 51.48   | 33.47   | 87.02   |
| 13/5/30  | 41.79   | 48.70   | 61.24   | 137.70  |
| 20/5/30  | 26.96   | 37.82   | 25.03   | 97.29   |
| 27/5/30  | 21.50   | 25.60   | 31.03   | 60.08   |
| 3/6/30   | 50.95   | 33.49   | 42.60   | 63.52   |
| 12/6/30  | 37.31   | 31.97   | 31.98   | 95.76   |
| 17/6/30  | 25.03   | 36.35   | 41.80   | 73.79   |
| 24/6/30  | 24.92   | 33.78   | 36.56   | 57.32   |
| 1/7/30   | 33.17   | 37.92   | 54.14   | 82.96   |
| 9/7/30   | 42.41   | 51.57   | 54.80   | 49.66   |
| 15/7/30  | 36.42   | 30.43   | 34.06   | 28.65   |
| 22/7/30  | 27.21   | 33.24   | 43.45   | 52.11   |
| 29/7/30  | 23.79   | 31.50   | 28.82   | 40.20   |
| 7/8/30   | 31.56   | 31.28   | 36.89   | 59.69   |
| 13/8/30  | 26.52   | 30.58   | 31.70   | 20.47   |
| 26/8/30  | 23.18   | 34.72   | 28.07   | 35.60   |
| 25/9/30  | 36.93   | 43.79   | 49.41   | 27.56   |
| 30/9/30  | 27.43   | 33.27   | 27.06   | 15.73   |
| 7/10/30  | 18.30   | 22.10   | 28.08   | 38.35   |
| 14/10/30 | 23.37   | 21.29   | 33.69   | 18.94   |
| 21/10/30 | 27.82   | 21.62   | 28.03   | 27.18   |
| 28/10/30 | 28.67   | 29.01   | 29.50   | 14.71   |
| 5/11/30  | 26.79   | 40.49   | 36.48   | 25.74   |
| 11/11/30 | 17.68   | 42.42   | 22.08   | 24.12   |
| 18/11/30 | 21.23   | 33.32   | 33.19   | 36.82   |
| 25/11/30 | 25.61   | 62.41   | 41.42   | 503.50  |
| 2/12/30  | 21.67   | 79.21   | 39.45   | 1259.00 |
| 9/12/30  | 22.83   | 59.98   | 44.84   | 253.80  |
| 16/12/30 | 16.66   | 39.53   | 58.57   | 327.80  |
| 31/12/30 | 20.93   | 49.98   | 41.81   | 125.00  |
| 6/1/31   | 19.68   | 54.11   | 37.62   | 251.30  |

FIGURE 1



numbers due to the stable manure is the result of the nitrogen contained in it. A count of the numbers of bacteria in the actual sample used was not made. It has been shown, however, that sterilised manure will produce an even greater effect on bacterial numbers than the same manure unsterilised.

**Table 2.**

Effect of Hoof and Horn on the number of Bacteria in Soil.  
Manure applied 15/2/30 and 18/11/30.

| Date.   |     | Numbers<br>(Millions). | Date.    |     | Numbers<br>(Millions). |
|---------|-----|------------------------|----------|-----|------------------------|
| 18/2/30 | ... | 30·07                  | 18/11/30 | ... | 36·82                  |
| 25/2/30 | ... | 335·70                 | 25/11/30 | ... | 503·50                 |
| 4/3/30  | ... | 252·00                 | 2/12/30  | ... | 1259·00                |
| 11/3/30 | ... | 164·80                 | 9/12/30  | ... | 253·00                 |
| 18/3/30 | ... | 428·70                 | 16/12/30 | ... | 327·80                 |
| 1/4/30  | ... | 335·30                 | 31/12/30 | ... | 125·00                 |
| 8/4/30  | ... | 87·84                  | 6/1/31   | ... | 251·30                 |

It is therefore generally agreed that the increase is due to the nitrogen and minerals added to the soil in the manure and not to the actual introduction of bacteria.

#### **Effect of temperature.**

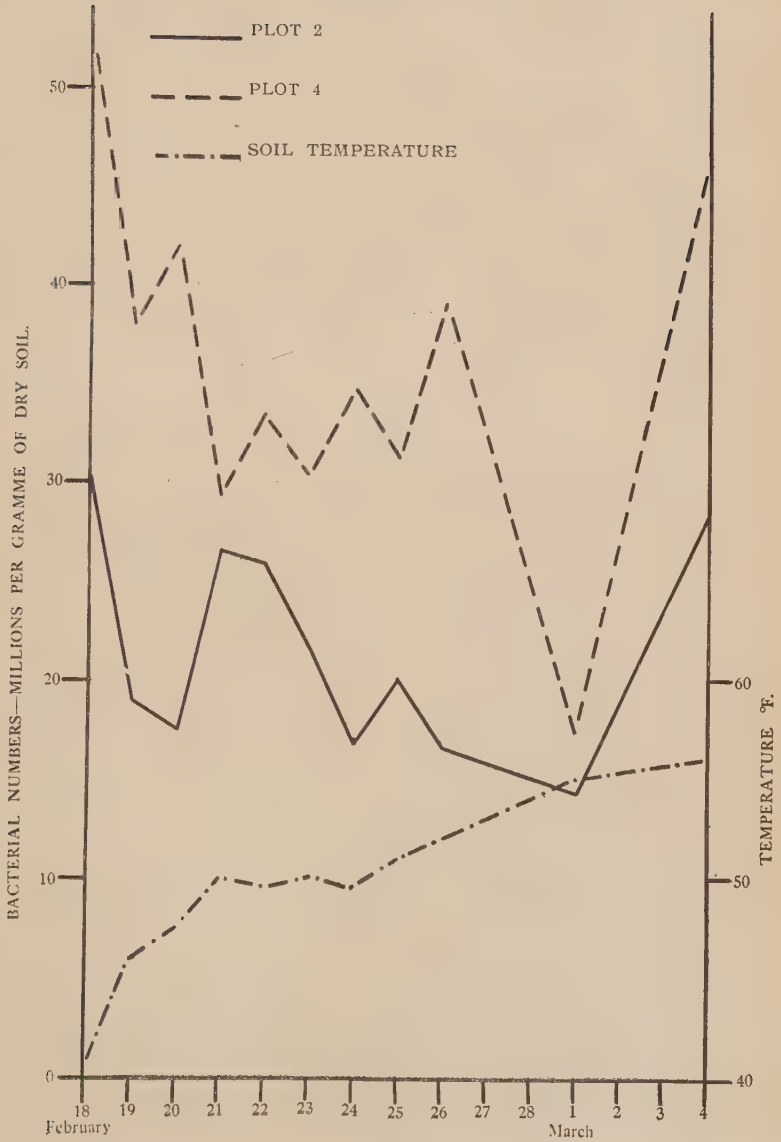
It was noted in 1929 that the bacterial numbers decreased after the fires had been lit and the soil temperature thereby raised. This was contrary to expectation and it was thought that the period of sampling was too long to show any temporary increase that might occur. Accordingly in 1930, daily samples were taken in Plots 2 and 4 for over a week after the fires had been lit. The results are shown in Table 3 and in Fig. 2.

**Table 3.**

Effect of Temperature of the Soil on Bacterial Numbers.

| Date.   |     | Temperature<br>°F. |     | Plot 2<br>(Millions). |     | Plot 4<br>(Millions). |
|---------|-----|--------------------|-----|-----------------------|-----|-----------------------|
| 18/2/30 | ... | 40·5               | ... | 30·73                 | ... | 52·74                 |
| 19/2/30 | ... | 46·0               | ... | 18·99                 | ... | 38·05                 |
| 20/2/30 | ... | 47·5               | ... | 17·47                 | ... | 41·92                 |
| 21/2/30 | ... | 50·0               | ... | 26·55                 | ... | 29·36                 |
| 22/2/30 | ... | 49·5               | ... | 25·84                 | ... | 33·44                 |
| 23/2/30 | ... | 50·0               | ... | 21·58                 | ... | 30·52                 |
| 24/2/30 | ... | 49·5               | ... | 16·69                 | ... | 34·72                 |
| 25/2/30 | ... | 51·0               | ... | 20·06                 | ... | 31·25                 |
| 26/2/30 | ... | 52·0               | ... | 16·59                 | ... | 39·04                 |
| 1/3/30  | ... | 55·0               | ... | 14·33                 | ... | 17·33                 |
| 4/3/30  | ... | 56·0               | ... | 28·35                 | ... | 46·44                 |

FIGURE 2.





It was also possible to estimate the direct effect of temperature on bacterial numbers under natural conditions by comparing two chambers in House 6, in one of which the soil was electrically heated. In this case, despite the difference in temperature, the variations in the two chambers were strictly parallel. They are shown in Table 4 and Fig. 3.

**Table 4.**  
Numbers of Bacteria in Heated and Unheated Soil.

| Date.   | Heated.      |    |                        |       | Unheated.    |    |                        |       |
|---------|--------------|----|------------------------|-------|--------------|----|------------------------|-------|
|         | Temp.<br>°F. |    | Numbers<br>(Millions). |       | Temp.<br>°F. |    | Numbers<br>(Millions). |       |
| 26/2/30 | ...          | 61 | ...                    | 55.29 | ...          | 59 | ...                    | 79.97 |
| 27/2/30 | ...          | 62 | ...                    | 51.82 | ...          | 60 | ...                    | 88.86 |
| 28/2/30 | ...          | 64 | ...                    | 50.25 | ...          | 61 | ...                    | 78.21 |
| 1/3/30  | ...          | 65 | ...                    | 80.85 | ...          | 59 | ...                    | 98.74 |
| 3/3/30  | ...          | 69 | ...                    | 43.93 | ...          | 61 | ...                    | 49.98 |
| 4/3/30  | ...          | 69 | ...                    | 51.10 | ...          | 61 | ...                    | 61.30 |
| 5/3/30  | ...          | 69 | ...                    | 38.45 | ...          | 63 | ...                    | 40.71 |
| 6/3/30  | ...          | 69 | ...                    | 31.77 | ...          | 63 | ...                    | 46.48 |

From these results it is evident that temperature has no direct effect on the numbers of bacteria in the soil. In this connection attention may be drawn to the high numbers found in early February when the temperature was low.

#### **Effect of watering on bacterial numbers.**

In 1929, the first heavy watering of the season was followed by a rapid fall in the numbers of bacteria. This has not been confirmed in the present season. During the first fortnight in May when watering commenced and the house received three heavy waterings, the bacterial numbers in all the plots rose and remained at a high level.

In the meantime, a preliminary experiment had been carried out in order to investigate further the supposed washing out of bacteria from the top layers of the soil by heavy watering.

The experiment was carried out in House 2, using a lysimeter constructed in the early part of the year. When sampling, a hole was dug to a depth of 15 inches. Samples could then be taken from the side of the hole at varying depths. The plot was watered on May 2nd, 5th and 8th, samples on these days being taken after watering.

The results are shown in Table 5 and Fig. 4, which include a preliminary sample taken on April 11th.

FIGURE 3.

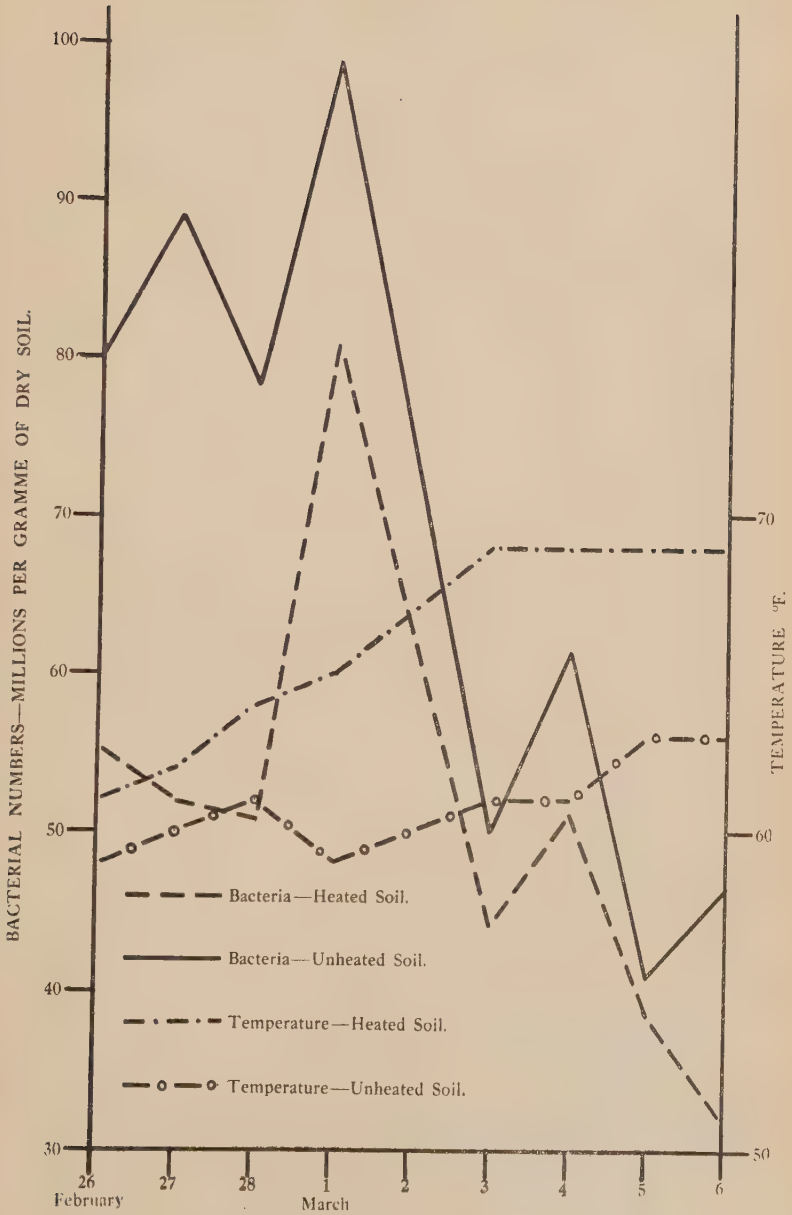
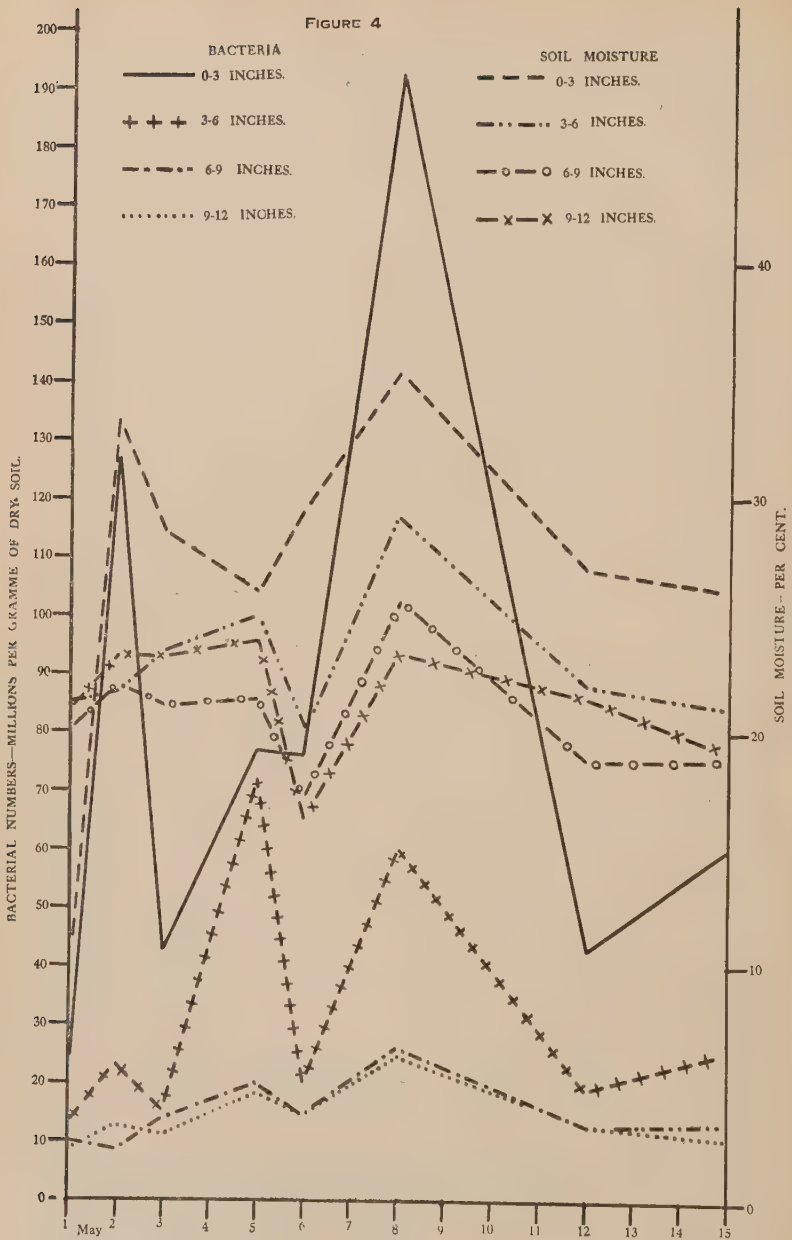


FIGURE 4



**Table 5.**

Effect of watering on the numbers of Bacteria at different levels in the soil.

| Date.   | 0-3 inches.            |                         | 3-6 inches.            |                         | 6-9 inches.            |                         | 9-12 inches.           |                         |
|---------|------------------------|-------------------------|------------------------|-------------------------|------------------------|-------------------------|------------------------|-------------------------|
|         | Moisture.<br>Per cent. | Numbers.<br>(Millions). | Moisture.<br>Per cent. | Numbers.<br>(Millions). | Moisture.<br>Per cent. | Numbers.<br>(Millions). | Moisture.<br>Per cent. | Numbers.<br>(Millions). |
| 11/4/30 | 20.04                  | 64.69                   | 23.71                  | 31.78                   | 22.95                  | 19.61                   | 24.27                  | 16.33                   |
| 1/5/30  | 9.36                   | 21.10                   | 21.30                  | 14.25                   | 20.12                  | 9.73                    | 21.08                  | 9.08                    |
| 2/5/30  | 33.37                  | 127.00                  | 21.76                  | 23.25                   | 21.96                  | 8.96                    | 23.21                  | 12.99                   |
| 3/5/30  | 28.57                  | 42.68                   | 23.48                  | 16.43                   | 21.15                  | 13.87                   | 23.20                  | 11.64                   |
| 5/5/30  | 25.96                  | 77.76                   | 24.98                  | 72.23                   | 21.43                  | 19.18                   | 23.90                  | 18.45                   |
| 6/5/30  | 29.60                  | 76.74                   | 20.23                  | 20.19                   | 17.33                  | 14.54                   | 16.29                  | 14.71                   |
| 8/5/30  | 35.44                  | 193.50                  | 29.18                  | 60.12                   | 25.51                  | 26.41                   | 23.36                  | 24.79                   |
| 12/5/30 | 27.02                  | 42.86                   | 22.05                  | 18.98                   | 18.80                  | 13.66                   | 21.43                  | 13.66                   |
| 15/5/30 | 26.11                  | 59.27                   | 21.03                  | 25.89                   | 18.79                  | 13.72                   | 19.14                  | 10.96                   |

It will be seen that there is a large increase in the number of bacteria in the top 3 inches immediately after the watering, followed by a rapid decrease. The fluctuations near the surface are followed to a less extent up to a depth of 6 inches. Below that depth there is little change in the numbers, but the effect is still seen. There is no evidence of bacteria being washed down into lower levels in the soil. Apart from this temporary increase in numbers, when the water is first applied, the humidity of the soil does not appear to influence the bacterial numbers to any extent.

### Discussion.

It is difficult to separate the effects of various factors when considering the causes for the rapid fluctuations in bacterial numbers. From the data obtained in two years' work it would appear that the only factor in these soils which produces any striking effect is the presence of organic nitrogen. In 1929 it was found that the absence of phosphates, potash and mineral nitrogen did not materially affect the changes in numbers. This year, it has been shown that soil temperature and humidity are not responsible. Only where organic nitrogen was added, either as stable manure or as hoof and horn, has there been a large and long continued increase in the bacteria. It may be suggested that the nitrogen content of the soil is the controlling factor in producing the rapid fluctuations in bacterial numbers shown by all the plots. The nitrogen is used up in forming the complex compounds which build up living protoplasm. The numbers increase until a maximum is reached and then fall again until more nitrogen is released by the decay of the dead bacteria and other organic remains in the soil.

## Summary.

(1) In continuation of work commenced in 1929, the numbers of bacteria in certain soils have been determined at weekly intervals throughout the season.

(2) It is shown that changes in bacterial numbers cannot be correlated with changes in soil temperature and humidity.

(3) The addition of stable manure and hoof and horn increases the numbers of bacteria to a marked extent.

(4) It is suggested that the presence of organic nitrogen may be the cause of the rapid fluctuations in numbers throughout the season.

## 2. Tomato Leaf Mould.

By T. SMALL.

### Fungicides.

Protective action of fungicides. To determine the protective action of fungicides, plants, previously sprayed with the fungicide and allowed to dry, were gently inoculated with a heavy suspension of spores in water, placed in a moist chamber for three days and subsequently grown in a glasshouse. Five plants, each about 10 inches high, were used in each trial. Controls received similar treatment except that they were left unsprayed or were sprayed with spreader only. Saponin (0.02%) and Agral 1 (0.15%) were used as spreaders.

The results obtained are summarised in Table 1. Each experiment was repeated at least twice, and in all experiments the controls developed leaf mould severely except those sprayed with Agral 1.

**Table 1.**  
Control of leaf mould by fungicides.

| Fungicide.     |              |           |     | Conc.<br>(per cent.) | Control.      |               |
|----------------|--------------|-----------|-----|----------------------|---------------|---------------|
|                |              |           |     |                      | With Agral 1. | With Saponin. |
| Ammonium       | Copper       | Carbonate | ... | 0.50                 | ***           | ***           |
| „              | Polysulphide | ...       | ... | 0.40                 | ***           | ...           |
| „              | „            | ...       | ... | 0.50                 | ...           | **            |
| Calcium        | Bisulphite   | ...       | ... | 1.00                 | ***           | **            |
| Colloidal      | Bordeaux     | Mixture   | ... | 1.00                 | ...           | **            |
| „              | Sulphur A.   | ...       | ... | 0.40                 | ***           | ...           |
| „              | „            | ...       | ... | 0.50                 | ...           | ***           |
| „              | Sulphur B.   | ...       | ... | 0.40                 | ***           | ...           |
| „              | „            | ...       | ... | 0.50                 | ...           | **            |
| Lime           | Sulphur      | ...       | ... | 0.40                 | ***           | ...           |
| „              | „            | ...       | ... | 0.50†                | ...           | **            |
| Liver of       | Sulphur      | ...       | ... | 0.25†                | ***           | **            |
| Salicylanilide | ...          | ...       | ... | 0.25†                | ***           | ***           |
| Sodium         | Polysulphide | ...       | ... | 0.50                 | ...           | *             |
| Solbar         | ...          | ...       | ... | 1.00 & 2.00†         | ...           | *             |

† Slight scorch. No † denotes absence of scorch.  
 \* Poor, \*\* Fair, \*\*\* Fairly good, \*\*\*\* Good.

The results show that most fungicides gave better control of leaf mould with Agral 1 as a spreader than with saponin. Effective control was obtained by spraying with ammonium copper carbonate, colloidal sulphur A. and salicylanilide, while fairly effective control resulted on plants sprayed with ammonium polysulphide, calcium bisulphite, lime sulphur, liver of sulphur and colloidal sulphur B.

Preliminary trials have been made on nurseries with some of the promising fungicides. Occasionally the plants were scorched by liver of sulphur, salicylanilide, lime sulphur and ammonium polysulphide, but ammonium copper carbonate and colloidal sulphur A. were non-injurious and were considered by growers to be suitable for use on tomato crops. These trials will be continued in 1931.

Observations on nurseries from 1927 to 1930 show that the disease appears towards the end of April and often becomes severe in May and June. During this early part of the season the favourable environmental conditions for leaf mould which obtain in glasshouses can scarcely be avoided owing to unfavourable climatic conditions. It is during this period that spraying will probably prove most useful to growers. From July to September ample ventilation is usually given and this is often sufficient to prevent serious attacks of leaf mould provided that the disease has not become severe during May and June.

The interval between successive sprayings must be determined by trials and will depend upon whether conditions are favourable or unfavourable for the disease. At present an interval of two weeks is suggested during May and June, after which less frequent treatment will probably suffice to control the disease. Particular attention should be paid to those well-known areas of the nursery where leaf mould first appears and from which it spreads to the rest of the crop.

#### **Curative action of fungicides.**

The curative action of the fungicides shown in Table 1 was tested, using the same concentrations of fungicide and Agral 1 as those noted in the Table. The standard procedure was to clamp approximately equal-sized areas of diseased leaf tissue in a vertical position and to spray each of them for 10 seconds with 25 c.c. of the fungicide. When the tissue was quite dry some of the spores remaining on it were transferred to a weak glucose solution and tested for germination. Spores from the controls, which were sprayed with spreader only, germinated excellently.

The results showed that ammonium copper carbonate and ammonium polysulphide were the most toxic since they usually



killed about 95% of the spores. These two fungicides have been used to spray diseased crops but most growers preferred ammonium copper carbonate to ammonium polysulphide because the latter left a little deposit on the fruit and discoloured the paintwork of the houses.

In one test ammonium copper carbonate was used in a glasshouse containing one thousand severely diseased plants, five hundred of which were sprayed three times at fortnightly intervals with 0.50% ammonium copper carbonate in 0.15% Agral 1. The treatment checked the disease considerably.

### Fumigants.

In these experiments the plants were first inoculated with a spore suspension and allowed to dry. They were then exposed to the vapour of the fumigant for two hours in a dry, glass chamber (capacity 2.7 cubic feet and temperature 17°C. to 20°C.) in the laboratory, placed in a moist chamber for three days and subsequently grown in a glasshouse. Five plants, each about 10 inches high, were used in each trial, and the fumigants were vaporised by heating with a small flame. Controls were inoculated but were not exposed to the vapour, and they invariably developed leaf mould. During the trials, diseased leaves and glass slides dusted with spores were also placed in the fumigating chamber, and spores from these were tested for germination the day after fumigation.

Table 2 includes those fumigants which failed both to control leaf mould and to kill the spores on diseased leaves and glass slides. When used in amounts greater than those given in the Table, the fumigants injured the plants yet frequently failed to kill the spores. Sometimes the spores were killed on the glass slides but not on the diseased leaves.

**Table 2.**  
Fumigants which failed to control Leaf Mould.

| Fumigant.             | Amt. Oz. per<br>1,000 cu. ft. | Fumigant.             | Amt. Oz. per<br>1,000 cu. ft. |
|-----------------------|-------------------------------|-----------------------|-------------------------------|
| Acetophenone ...      | 1.30                          | Iodobenzene ...       | 1.00                          |
| Amyl alcohol ...      | 2.60                          | Methyl salicylate ... | 1.30                          |
| Anthraquinone ...     | 2.60                          | Nitrobenzene ...      | 1.30                          |
| Bromobenzene ...      | 0.26                          | Nitronaphthalene ...  | 0.20                          |
| Chloranil ...         | 2.00                          | o-nitrotoluene ...    | 0.65                          |
| o-cresyl-methyl ether | 1.30                          | p-nitrotoluene ...    | 1.30                          |
| p-dichlorobenzene ... | 2.00                          | Phenyl salicylate ... | 0.20                          |
| Dimethyl-aniline ...  | 1.30                          | Pyrocatechol ...      | 0.19                          |
| Epichlorhydrin ...    | 0.32                          | Quinoline ...         | 1.30                          |
| Ethyl benzoate ...    | 0.65                          | Resorcinol ...        | 1.30                          |
| Ethyl formate ...     | 3.91                          | Terpinol ...          | 1.30                          |
| Hydroquinone ...      | 2.60                          | Tetrachlorethane ...  | 1.30                          |

The fumigants shown in Table 3 prevented leaf mould from developing on inoculated plants and also killed the spores on both diseased leaves and glass slides.

**Table 3.**

Fumigants which controlled Leaf Mould.

| Fumigant.              | Amt. Oz. per<br>1,000 cu. ft. | Leaf Mould<br>attack. | Plant Injury.                               |
|------------------------|-------------------------------|-----------------------|---------------------------------------------|
| Ethylene dibromide ... | 2.60 ...                      | Negligible ...        | Stunting and hardening<br>effect sometimes. |
| Quinone ...            | 0.26 ...                      | „ ...                 | Nil.                                        |
| Thymol ...             | 0.45 ...                      | „ ...                 | Nil.                                        |

In later experiments quinone and thymol were tested under various environmental conditions in a glasshouse of 635 cubic feet capacity, and it was found that both compounds scorched the plants when used in amounts which caused no injury in laboratory experiments. Smaller amounts were then tried, but with thymol scorching occurred at concentrations which failed to control the disease. On the other hand, quinone at a concentration of 0.14 oz. per 1,000 cubic feet prevented leaf mould from developing on inoculated plants yet caused little or no scorching. In addition it killed the spores on glass slides but not those on diseased leaves. At a concentration of 0.08 oz. per 1,000 cubic feet quinone failed to control leaf mould. On account of the high price of quinone experiments have been made with a cheaper product and the results indicate that this product may be as effective as pure quinone.

The above experiments show that quinone vapour is very toxic to the spores of *C. fulvum*. Further work is necessary to ascertain if quinone fumigation is practicable for the control of tomato leaf mould in large glasshouses.

### **Sulphur Vapour.**

In these experiments the plants were inoculated with a spore suspension only on the lower side of the leaves, and when dry they were placed in a glasshouse of 635 cubic feet capacity in which 2 ozs. of flowers of sulphur were vaporised by Campbell's apparatus. Fumigations were carried out late in the afternoon, and next morning the plants were removed from the glasshouse, placed in a moist chamber for three days and subsequently grown under conditions favourable for leaf mould. Control plants were inoculated but were not exposed to the vapour, and they always developed the disease. Many trials were made but in none of them did ignition of the sulphur occur.

Experiments were made in which the temperature at the time of fumigation was 19°C., while in others it was 27°C. In some trials the humidity was high, in others it was low. Almost identical results were obtained under these very different sets of atmospheric conditions.

The results showed that plants in inverted positions during fumigation remained almost healthy, while plants in upright positions during fumigation developed a severe attack of leaf mould. Similar results were obtained in later trials in which the plants were inoculated after instead of before fumigation. The results are explicable on the supposition that the inoculated (lower) side of the leaves of inverted plants was covered with sulphur while that of upright plants received little, if any, sulphur.

From these and other results it was clear that plants in upright positions during fumigation were protected from infection only on the upper side of the leaves. Attempts were made, therefore, to determine on which leaf surface infection occurs under natural conditions. An experiment was made in which sixty small drops of a spore suspension were placed on the upper and lower sides of leaves, and the results showed that the number of infections was fifty-eight and fifty-nine respectively. It was also interesting to find that all the leaves inoculated on the upper side developed leaf mould only on the lower side. Thus the fact that the disease almost always occurs on the under side of leaves does not necessarily mean that infection takes place there. Efforts to ascertain on which leaf surface infection occurs under natural conditions were not successful and they are being continued.

It is worth noting that in the above experiments with sulphur vapour the spore pustules on the under side of the leaves of diseased plants in upright positions were not killed by the vapour.

#### **Fumigation of empty Glasshouses.**

It has been shown elsewhere that the spores of *C. fulvum* may overwinter on both glasshouse structures and diseased leaves, and that such spores may cause infection in the spring. (See Fifteenth Annual Report). Experiments were made, therefore, to ascertain if houses may be freed from infection by fumigation during the winter. The trials were made in a glasshouse of 25,000 cubic feet capacity, and the house was closed for about twenty hours from the commencement of fumigation. Seventy diseased leaves and thirty glass slides dusted with spores were placed in positions on the floor, roof and sides of the house, and spores from these were tested for germination the day after fumigation. Control spores, kept in

neighbouring glasshouse, germinated excellently. As a result of preliminary trials in a small glasshouse formaldehyde, cresylic acid and sulphur dioxide were selected for the experiments.

#### **Formaldehyde.**

The gas was generated by pouring a 40% aqueous solution of formaldehyde upon crystals of potassium permanganate. Each of four deep receptacles was charged with 1.25 pints of formalin and 0.8 pounds of potassium permanganate. The weather was fine but dull, and at the time of fumigation the temperature was 24°C., and the humidity 85%. Germination trials showed that practically every spore was killed by the treatment, which cost about six shillings. When half the above quantities were used spores in exposed places were killed but not those in crevices and in pipe hooks.

#### **Cresylic acid.**

One pint of pale straw cresylic acid was vaporised by each of two naphthalene lamps (Monros). The results showed that the spores were killed in some parts of the house but not in others, and suggested that the vapour was irregularly distributed.

#### **Sulphur dioxide.**

This gas was generated by burning flowers of sulphur. Preliminary trials in a small glasshouse of 635 cubic feet capacity showed that quick generation of the gas was essential. For example, 1.0 lb. of sulphur in one heap failed to kill the spores, whereas four heaps, each of 0.25 lb., burned simultaneously, killed almost every spore. Various experiments were made under very different environmental conditions and almost identical results were obtained.

In an experiment made in the large house of 25,000 cubic feet capacity, five heaps of sulphur, each of 5 lbs., were burned simultaneously, and the result showed that almost every spore was killed. The fumigation which cost about three shillings was carried out on a rainy day and the temperature at noon was 15°C. When half the above quantity was used the spores were killed except on two leaves near the apex of the roof.

The foregoing experiments indicate that large empty glasshouses may be freed from infection by fumigation with formaldehyde or sulphur dioxide. It is, perhaps, impracticable to fumigate large, unpartitioned blocks of houses, but in propagating houses or in houses where it is desired to re-plant immediately an area carrying a badly diseased crop, fumigation should be carried out in order to lessen the risk of infection.



### **Relation of leaf mould to environmental conditions.**

By the kindness of Mr. J. C. Cobley and Mr. E. S. Shoults the observations begun on their nurseries in 1929 were continued. Observations were also made on the Experimental Station nursery. On each nursery the work was carried out in a non-partitioned block of glasshouses in which leaf mould is usually severe in one area but is mild or absent in another area. In these areas, called diseased and non-diseased respectively, temperature and humidity records were taken by thermo-hygrographs. In each block of glasshouses the houses run north and south, are highest at the south end and, except on Nursery No. 2, stand on level ground.

#### **Nursery No. 1.**

Observations were made in a two-acre block of glasshouses in which leaf mould occurs at the south end, but is practically absent at the north end. Planting took place on 27th February, 1930, but the plants received no water till 7th April, 1930, after which they were watered once a week. Day ventilation was begun in March and night ventilation in May, while full day and night ventilation was given from July to September. The plants at the south end of the houses grew very freely.

Leaf mould was more severe than it was in 1929. It appeared in the diseased area 28th April, 1930, and was prevalent from June to September, while in the non-diseased area it was almost absent. It is worth noting that the disease appeared on 14th April, 1930, in another part of this nursery.

#### **Nursery No. 2.**

Observations were made in a 1·5 acre block of glasshouses which stand on an easterly slope, and in which the non-diseased and the diseased areas are situated respectively at the bottom and mid-way along the slope. On this nursery overhead damping was practised daily from mid-March, the time of planting, to the end of April, after which soil watering was given twice and occasionally three times a week. The amount of ventilation equalled that given in Nursery No. 1 except that night ventilation was not begun till 13th June, 1930. The plants did not grow too freely except in one house near the top of the slope.

Leaf mould was less severe than it was in 1929, in which year the plants grew freely in the steamed soil. It appeared in the diseased area 12th May, 1930, and in the non-diseased area 26th May, 1930. It developed more quickly in the former area, but even here the plants were not seriously affected. In this block of houses the disease was most severe on the soft plants near the top of the slope.

In a neighbouring block of glasshouses a very severe attack of leaf mould occurred in the three topmost houses where the plants were very soft, owing partly to the soil having been steamed for the 1930 season. The disease appeared 14th April, 1930, five weeks after planting, and was severe from May to September.

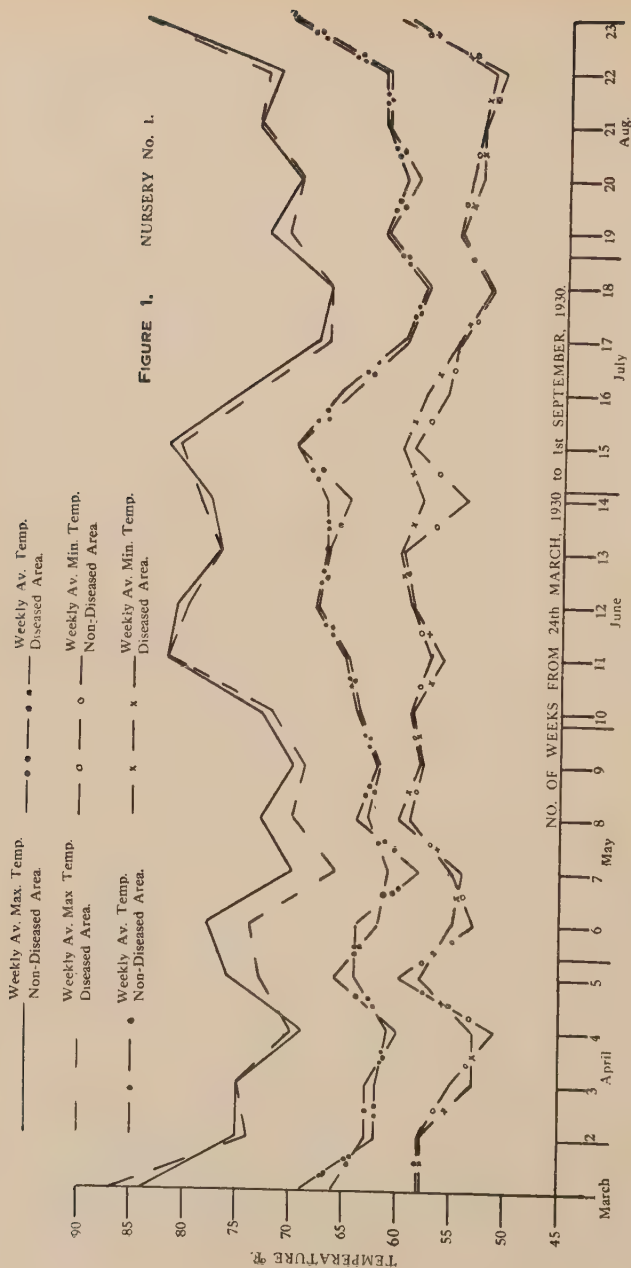
### Nursery No. 3.

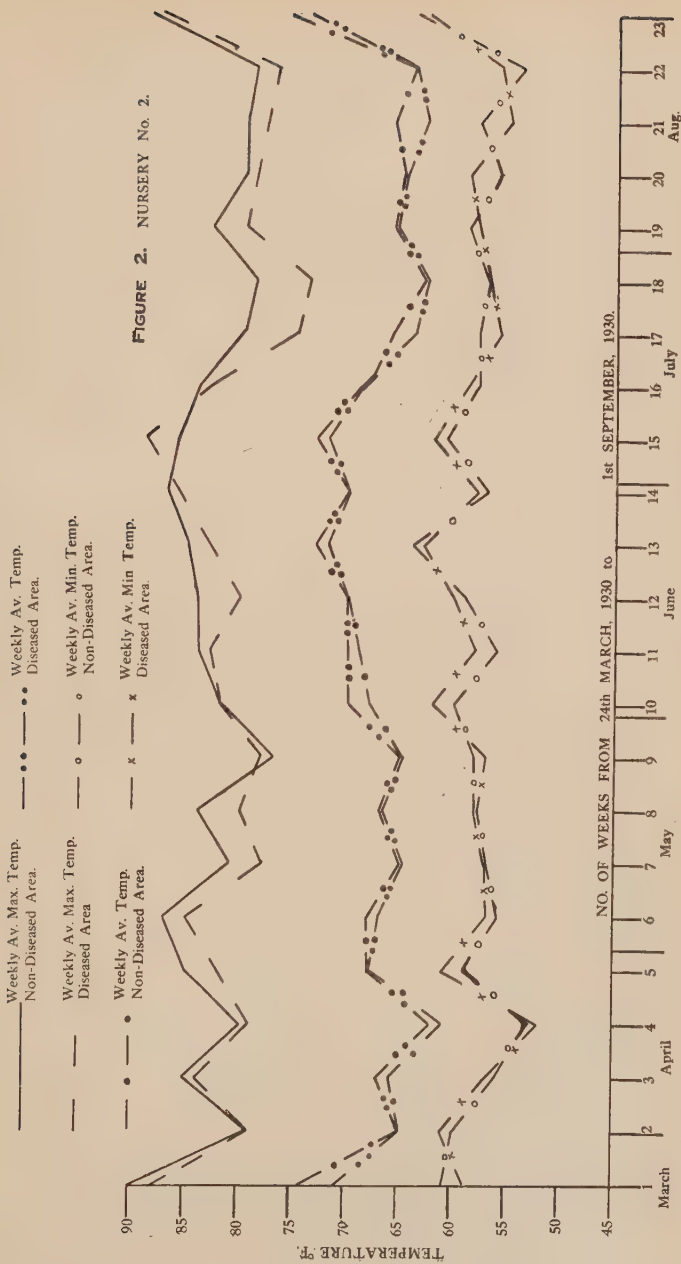
Observations were made in a  $\frac{1}{3}$  acre block of glasshouses in which the diseased and the non-diseased areas are situated in the east and west houses respectively. Overhead damping was practised almost daily from 27th February, 1930, the date of planting, to the end of April, after which soil watering was given once and occasionally twice a week. Day ventilation was begun 24th March, 1930, and night ventilation 3rd June, 1930, and full day and night ventilation was given during July and August.

Leaf mould was worse than it was in 1929. It appeared in the diseased area 15th April, 1930, and was severe in June and July, while in the non-diseased area it appeared 3rd May, 1930, and was far less severe.

Interesting points arising from the foregoing observations are as follows:—(a) The disease appeared five to six weeks after the plants were set in the houses and was prevalent or severe in May or June, *i.e.*, many weeks before pipe heating was discontinued and before condensation water was observed on the foliage in the early morning. Similar observations were recorded in 1921. (b) Of the three blocks of glasshouses under consideration, that in Nursery No. 2 received the most water yet suffered least from leaf mould. (c) As in 1929, soft, free-growing plants suffered most from leaf mould. (d) From the data available it is difficult to understand why both diseased and non-diseased areas should occur within a single unpartitioned block of glasshouses. Figs. 1, 2 and 3 show that almost similar temperatures obtained in both diseased and non-diseased areas, while Figs. 4, 5 and 6 show that the humidity was higher in the diseased areas especially during the day. At night, however, conditions favourable to leaf mould obtained for several hours even in non-diseased areas. Further, as shown in Fig. 7, the average humidity of a non-diseased area on one nursery may be as high or higher than that of a diseased area in another nursery. (e) During the summer pipe heating was discontinued in Nursery No. 3, but not in Nursery No. 2, but, as shown in Fig. 8, the average minimum night temperature in these two nurseries was almost identical.







Weekly Av. Max. Temp.  
Non-Diseased Area.

Weekly Av. Min. Temp.  
Diseased Area.

Weekly Av. Max. Temp.  
Diseased Area.

Weekly Av. Min. Temp.  
Non-Diseased Area.

Weekly Av. Max. Temp.  
Non-Diseased Area.

Weekly Av. Min. Temp.  
Diseased Area.

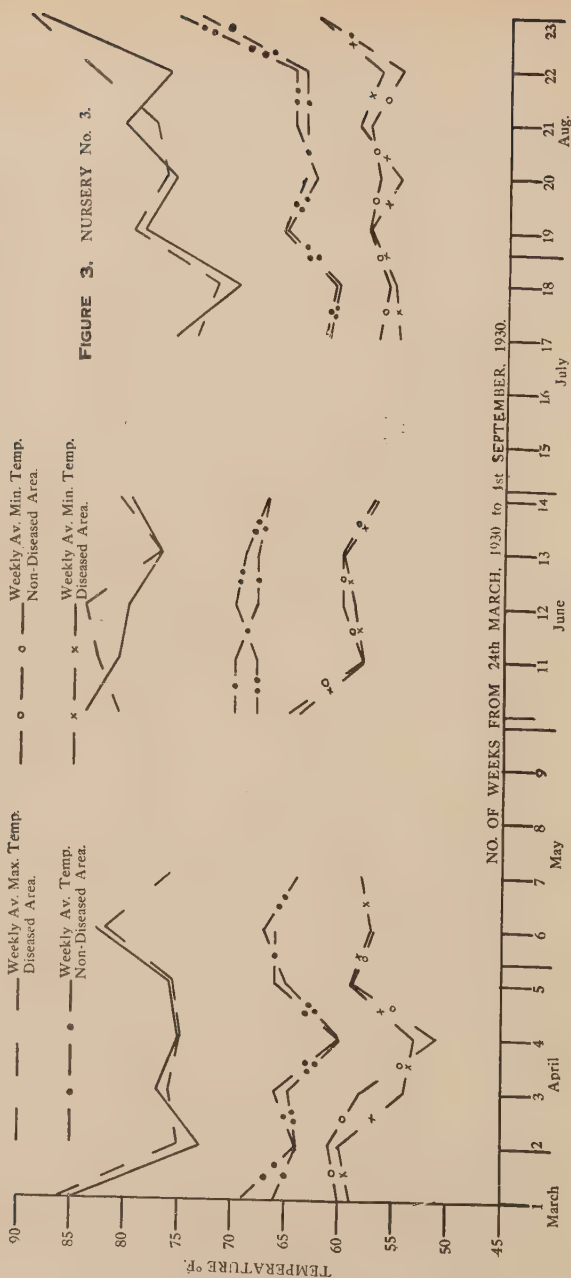


FIGURE 3. NURSERY No. 3.



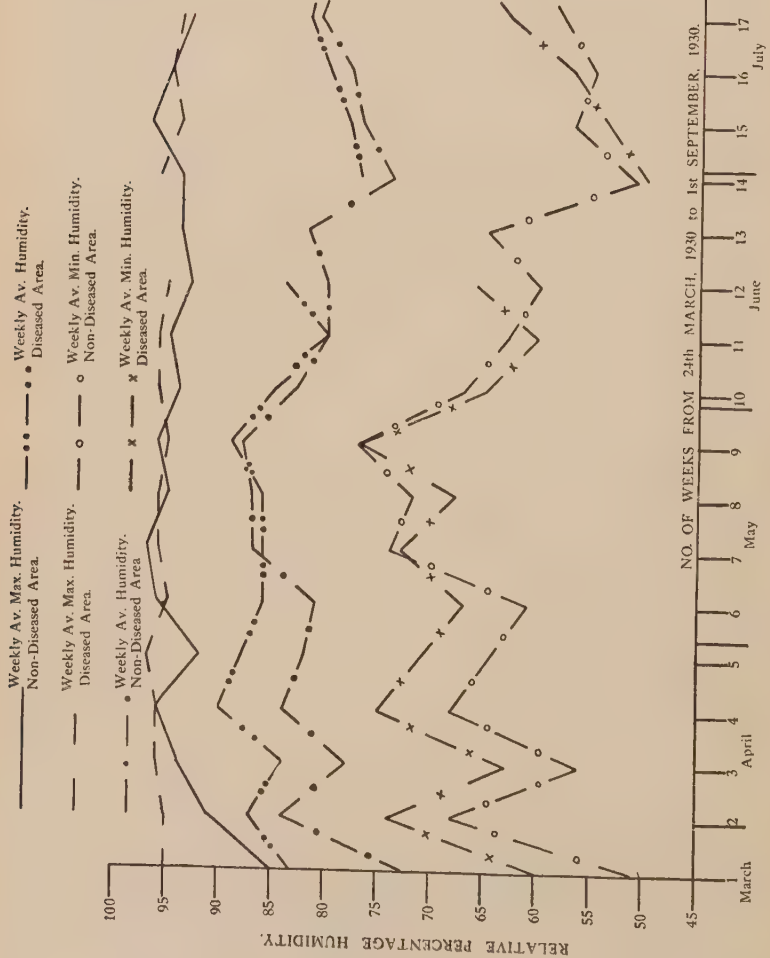
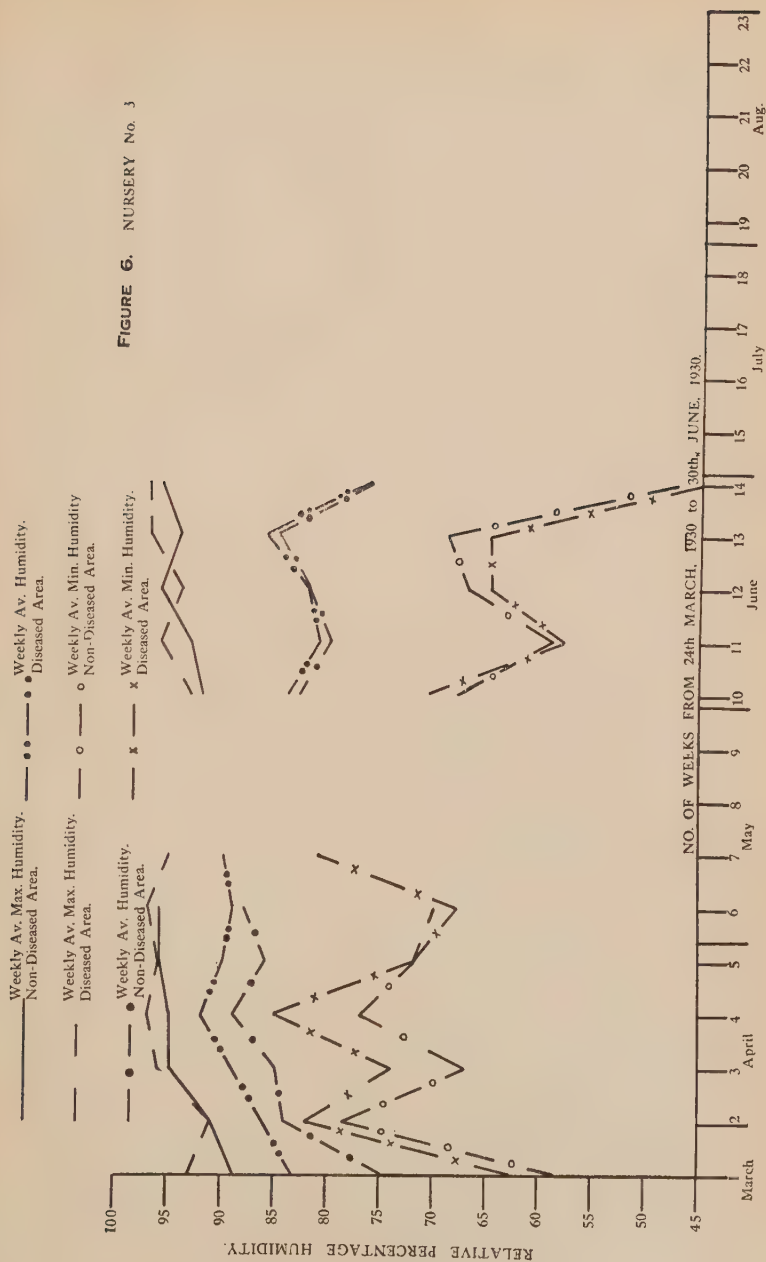
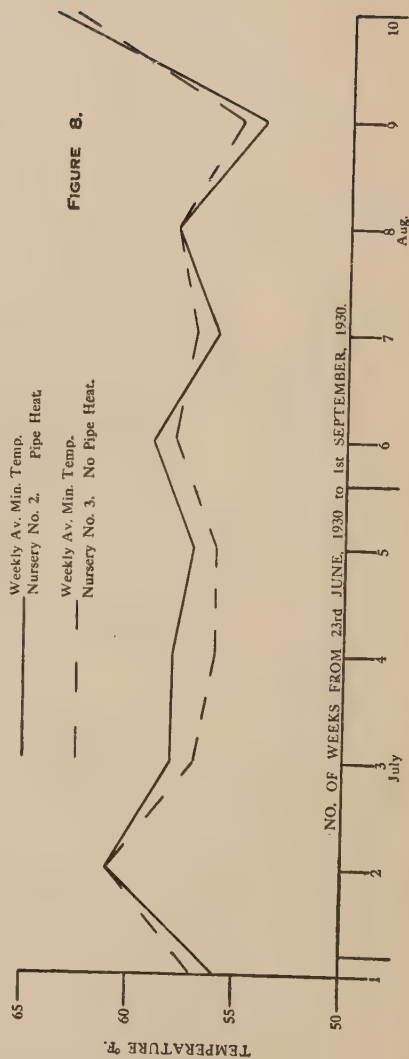
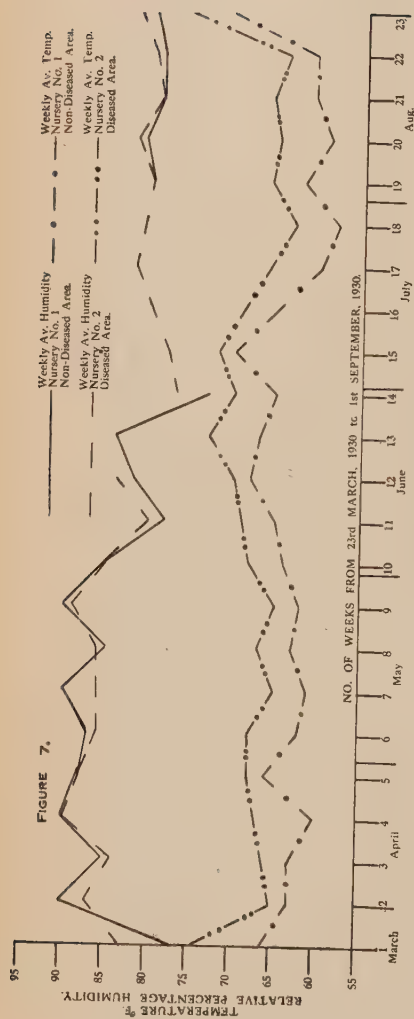


FIGURE 5. NURSERY No. 2.



FIGURE 6. NURSERY No. 3





### Experiments with spores.

(a) GERMINATION.—To determine the minimum, optimum and maximum temperatures for germination, spores from fresh diseased leaves were placed in hanging crop cultures at constant temperatures. The minimum temperature was not found but at 38°F., the lowest temperature tested, germination occurred in thirty-six hours. At the optimum temperature, 72°F. to 77°F., the spores germinated in three hours. The maximum temperature was 89°F. At 82°F. excellent germination occurred.

(b) INTERMITTENT GROWTH OF GERM TUBES. Experiments have shown that spores germinate in one night on the leaves of plants in the glasshouse. The germ tubes, however, are probably too short to establish infection and the question arises whether such germ tubes can withstand dry, day conditions, and whether they resume growth at night when humid conditions again obtain.

To acquire information on these points spores were allowed to germinate in water and were dried when the germ tubes had grown sufficiently. Upon wetting the spores six hours later the germ tubes resumed growth. This treatment was repeated next day and similar results were obtained. The results show that the germ tubes can withstand considerable dry periods.

(c) THERMAL DEATH POINT. Spores from diseased leaves were placed in water at a constant temperature for ten minutes and were afterwards cooled quickly and tested for germination. The thermal death point of the spores was 115°F. (46°C.). At 105°F. very few spores were killed.

(d) EXPOSURE TO HIGH TEMPERATURES.—During hot weather from 30th June, 1930, to 8th July, 1930, diseased leaves were kept in a glasshouse which was closed daily from 11 a.m. to 5 p.m. Each day the temperature of the house was above 100°F. for several hours, while the maximum temperature was between 110°F. and 130°F. At intervals spores from the leaves were tested for germination, and the results showed that almost all the spores germinated in every test, including the one made on 8th July, 1930. The results indicate that spores on diseased plants would not be killed by closing the glasshouses at mid-day in sunny weather.

During the above experiment five inoculated plants were kept in the glasshouses from 4th July, 1930, to 8th July, 1930, after which they were placed in a moist chamber for three days and subsequently grown under conditions favourable for leaf mould. These plants developed the disease, thus showing that the spores were not killed by exposure to high tempera-

tures in the closed glasshouse. In this experiment dry atmospheric conditions obtained. In a later experiment, in which humid conditions were maintained in the closed glasshouse, the spores were killed by the high temperatures, but this point was not definitely established owing to the onset of cooler weather conditions.

### Summary.

(1) Experiments have been made on the control of tomato leaf mould (*C. fulvum*) by fungicides and fumigants. Most fungicides gave better control of the disease with Agral 1 than with saponin as a spreader. Effective control resulted on pot plants sprayed with ammonium copper carbonate, colloidal sulphur A. and salicylanilide. It was also shown that ammonium copper carbonate was useful for spraying diseased crops.

(2) The disease was controlled by the fumigants, ethylene di-bromide, quinone and thymol, in laboratory experiments, and by quinone in trials made in a small glasshouse.

(3) Sulphur fumigation with Campbell's apparatus protected only the upper side of the leaves from infection and failed to kill the spores on the under side of diseased leaves. Inoculation tests showed that infection may occur on either side of the leaf.

(4) It has been shown that large empty glasshouses may be practically freed from infection by fumigation with formaldehyde or sulphur dioxide.

(5) An account is given of a study of the relation of leaf mould to environmental conditions on commercial nurseries.

(6) The minimum, optimum and maximum temperatures for germination of the spores of *C. fulvum* are below 38°F., 72°F.—77°F. and 89°F. respectively. It is shown that the germ tubes can withstand considerable dry periods. The thermal death point of the spores is 115°F. Spores on diseased leaves were not killed by exposure to high temperatures on several successive days.

## 3. Mosaic Disease of the Tomato.

By W. F. BEWLEY and W. CORBETT.

Mosaic disease of the tomato is to be found on most commercial nurseries and wherever tomatoes are grown, the extent of injury varying considerably in different places. It has been observed frequently while the plants were still in pots in the propagating houses. During November to March the symptoms are usually of the filiform type. Mottling is absent,

but the lamina of the leaf is often so severely distorted that it is drawn out in tendril fashion and blistering is common. Later in the year, the true filiform symptoms rarely occur, being replaced by light green or yellow mottling and distortion of the leaf outline. All distorted plants are rejected when planting in the houses at the end of February. Growth is slow for some weeks after planting, and usually mosaic symptoms are not noticeable. Towards the end of March sporadic cases of mosaic may be noticed, the symptoms occurring on the young leaves in the form of mottling and leaf distortion. During April growth is rapid, pruning and tying have been in progress some two or three weeks, and secondary infections are common. As the plants develop and fruit is formed, mosaic symptoms may cease to appear on the youngest leaves of infected plants, and those leaves which were badly mottled in March have assumed almost normal appearance. Indeed the mottling that remains may easily be confused with that associated with root injury such as may be produced by water-logged soil. The above temporary recovery only applies to normal plants cultivated under the best conditions. Those weakened by unsuitable soil conditions do not recover but retain severe symptoms which may extend to the flowers, many of which fall prematurely.

In commercial practice the growing point of the plant is removed at the second leaf above the fourth or fifth truss, for the purpose of checking vegetative growth and assisting the fruit to swell and ripen. Afterwards growth is continued by tying in a lateral shoot to take the place of the "stopped" stem. Growth of the lateral shoots is relatively slow while much of the lower fruit remains, but when the bottom crop has been picked the top growth develops with great rapidity. Much of it is soft and this stage of the plant's development is recognised by growers as being particularly prone to mosaic disease. Experiment suggests that the process of stopping is responsible for widespread infection, and that the severity of the symptoms is due to the type of growth, which frequently is soft and weak as the result of heavy cropping and rapid, unbalanced growth. Later the top shoots on normal plants gradually ripen and mosaic symptoms become less severe, but unless the plants are abnormally strong their crop production is reduced as the result of the infection. When the plants remain alive until November it is noticeable that mottling tends to become gradually reduced and that symptoms return to the filiform type noted for November to March in young plants. It is obvious therefore that symptoms of tomato mosaic vary in accordance with the physical factors of the environment, and the type of growth developed by the host.



Two main types of tomato mosaic are accepted in this country. One, the "ordinary mosaic" disease, may be recognised by the mildness of its symptoms, which are distortion and blistering in the winter (filiform type), and a pale yellowish green mottle accompanied by distortion during late winter to early autumn. Rarely does any mottling appear on the fruits. The second type, "aucuba" or "yellow mosaic," is most serious and severe. It resembles ordinary mosaic but the mottling is a fierce yellow colour, and yellow, orange and silver blotches appear on the fruits, which frequently develop patterns resembling those of a Paisley shawl. Further, this form materially affects the general growth of the plants, many of which may be severely crippled.

The constant association of "stripe" disease and mosaic disease suggests a definite relationship. "Stripe" disease was attributed to *Bacillus lathyri*, Manns and Taub, by Paine and Bewley, but recent workers, Dickson and Vanterpool, claim that it is due to a mixed virus. Berkeley, however, does not accept the latter explanation.

Outbreaks of "stripe" diseases frequently occur under glass in this country at a time when rapidly growing tomato plants, having reached a height of about three feet, develop soft, sappy tissues highly susceptible to this disease. Cases are known where several thousand plants on different nurseries have been so severely attacked that recovery seemed hopeless. They have, however, been induced to grow away from the disease and develop new top growth either by suitable applications of sulphate of potash or by increasing the temperature. In a large proportion of cases the top growth, while free from "stripe" lesions have developed symptoms of mosaic disease, either of the "aucuba" or the "ordinary" type.

#### **The effect of "aucuba" mosaic disease on tobacco.**

Experiments since 1924 have shown without doubt that when "aucuba" mosaic disease of the tomato is transmitted to the tobacco by inoculation with either crushed tissue or filtered virus, a violent and progressive necrosis results. The following Table, Table 1, indicates the results of a series of such inoculation experiments.

In other experiments tobacco plants inoculated with crushed tissue attacked by ordinary mosaic have developed a similar necrosis.

The following Table shows that over a period of years necrosis has been produced consistently in tobacco in a large proportion of cases. When the necrotic tobacco tissue is



crushed and inoculated back into tomato, aucuba symptoms develop, an occasional plant showing necrosis typical of "stripe" disease. The results are given in Table 2.

**Table 1.**

Results of inoculation experiments with "aucuba" mosaic.

| Date.    | Inoculum.                                                                    | No. of plants inoculated. | No. of plants showing necrosis. |
|----------|------------------------------------------------------------------------------|---------------------------|---------------------------------|
| 22/5/25  | Expressed juice from infected tobacco plants                                 | 8                         | 8                               |
| 26/5/25  | Expressed juice from infected tomato plants                                  | 6                         | 6                               |
| 10/9/25  | Crushed tissue from infected tomato plants                                   | 12                        | 11                              |
| 24/5/28  | " " " " " "                                                                  | 8                         | 5                               |
| 10/6/28  | " " " " " "                                                                  | 10                        | 8                               |
| 23/6/28  | " " " " " "                                                                  | 10                        | 7                               |
| 12/7/28  | " " " " " "                                                                  | 10                        | 8                               |
| 12/7/28  | Expressed juice from infected tomato plant filtered through L3 filter ... .. | 10                        | 4                               |
| 23/7/28  | Crushed tissue from infected tomato plants                                   | 20                        | 13                              |
| 29/7/29  | " " " " " "                                                                  | 6                         | 6                               |
| 23/10/29 | " " " " " "                                                                  | 5                         | 3                               |
| 15/1/30  | Crushed tissue from infected tobacco plant                                   | 10                        | 10                              |
| 24/1/30  | Crushed tissue from infected tomato plant                                    | 20                        | 20                              |

**Table 2.**

Results of inoculating tomato plants with crushed necrotic tissue.

| Date.   | No. of plants inoculated. |     |    | No. of plants which developed aucuba mosaic. |     |    | No. of healthy plants. |   |
|---------|---------------------------|-----|----|----------------------------------------------|-----|----|------------------------|---|
| 25/6/28 | ...                       | ... | 10 | ...                                          | ... | 6  | ...                    | 4 |
| 31/7/28 | ...                       | ... | 25 | ...                                          | ... | 25 | ...                    | — |
| 24/1/30 | ...                       | ... | 8  | ...                                          | ... | 8  | ...                    | — |
| 27/1/30 | ...                       | ... | 15 | ...                                          | ... | 15 | ...                    | — |

**Description of tobacco necrosis following inoculation with the virus of tomato "aucuba" mosaic.**

The inoculations with crushed tissue were performed by making an incision in the stem of a young plant four to five inches in height, at a point about one inch above soil level, inserting the inoculum and wrapping the wound with oiled silk kept in place by lead foil.

Filtered virus was pricked into the axil of a leaf in a similar position, the wound being covered as before.

Five to eleven days after inoculation a lesion appeared as a brown sunken area round the wound, but usually the first indication of disease was a dark brown streak, in some cases almost black, spreading upwards from above the point of

inoculation. This lesion spread rapidly and passed along the midribs of the leaves in its passage upwards. From the main veins necrosis travelled along the secondaries, the youngest leaves curled and isolated necrotic spots were produced over their surface. The lesions spread round the stem and from fourteen to twenty-one days after inoculation the entire plant, with the probable exception of the two oldest leaves, was involved.

Usually the plant died, but sometimes the ferocity of the infection suddenly ceased, the top grew away, and mosaic symptoms developed in the new leaves. On cutting open the stem of bad cases the entire tissue was dark brown in colour with some almost black areas, and the necrosis had travelled to within a few millimetres of the growing point. Here and there the tissues showed characteristic hollows in the brown areas. In the least severe cases, necrosis was restricted to the pith, and the vascular ring, but usually some part of the cortex was also involved.

Recently Jochems has described a new virus disease of Deli Tobacco, under the name of the Rotterdam B-disease, the symptoms of which correspond closely with those described above. It is interesting to record also that in 1914 Allard noted a "progressive and destructive rot" of the tissues of *Nicotiana langsdorffii* and *N. rustica* when these plants were inoculated with mosaic virus from the tobacco.

#### **Isolations of bacteria from the necrotic tissue.**

Numerous isolations on various kinds of nutrient media, both liquid and solid, have been made during the last six years. Frequently no obvious growth occurred in the media, but in many cases bacterial growth resulted. A yellow organism resembling *Bacillus lathyri*, Manns and Taub, appeared consistently, and was sometimes accompanied by a white bacillus of similar size. In 1928 a very small short rod, approximately  $0.4 \times 0.3$  was found in some yellow cultures. All attempts to separate the two by plating failed, and pure cultures of the small organism were ultimately obtained by streaking on the surface of potato agar plates.

The following reactions were obtained in the usual manner.

#### **Bouillon agar, streak.**

Growth was good, glistening, dark yellow down the centre with paler yellow edge. In old cultures pale yellow colonies had a verrucose blistered appearance. The edge became rugose. Dark yellow colonies gave rise to similar dark colonies, but the pale yellow colonies produced some dark colonies.

**Bouillon gelatine, stab.**

Growth on this medium was slow, particularly along the stab; growth of the surface colony was noticeable after three days. After eighteen days the growth along stab was villous; surface colonies were undulate, rugose and raised in centre. Liquefaction occurred only after several months.

**1% Peptone solution, 2% glucose.**

A slight clouding of the medium occurred after three days and later growth tended to become flocculent. After ten days a yellow ring began to form round the top of the medium; there was no pellicle. A heavy yellow precipitate formed and the ring round the top of the medium increased in size. No acid or gas was produced.

**1% Peptone solution, 2% lactose.**

As for glucose.

**1% Peptone solution, 2% sucrose.**

As for glucose.

**1% Peptone solution, 2% glycerine.**

As for glucose.

**Uchinsky's solution.**

No growth after several weeks.

**Milk.**

Very little growth after several weeks. No curding or peptonisation. A yellow ring eventually formed round the top of the medium and a yellow precipitate also began to form.

**Litmus Milk.**

As for milk. No acid produced.

**Bouillon.**

A definite clouding of the medium was noticeable after thirty-six hours, a yellow precipitate began to form after four days; and a ring, at first grey but later bright yellow, formed round the top of the medium. Occasionally small colonies floated on the surface but no pellicle was formed.

**Bouillon, 1% potassium nitrate.**

Growth as for bouillon. No reduction of nitrates.

**Dunham's solution.**

Growth similar to that in bouillon.

**Potato cubes.**

Growth very slow, glistening, bright yellow. No discolouration of medium. No diastatic action.

### **Inoculation experiments.**

From 1924 to 1927 repeated stab inoculations of young tomato, tobacco and petunia plants have been performed. The plants have been grown in sterilised soil and kept free from insect visitors. The tomato has failed to react to inoculation, but at frequent intervals necrosis has resulted in both tobacco and petunias. Further, when tomato plants have been inoculated with the crushed necrotic tissue mosaic has resulted in almost every case. Unfortunately the proportion of plants which reacted to inoculation in comparison to the number inoculated has been only of the order of 1 in 10.

Similar results have occurred since 1928 when cultures of the small organism just described have been used.

Having regard to the transmission of mosaic disease in the seed of tomato, tobacco and petunia, no guarantee can be given that the plants inoculated were actually clean, although they appeared so at the time of inoculation and all controls remained healthy.

Until a higher proportion of plants can be induced to develop necrosis on inoculation the results must be regarded with suspicion.

## **4. Physiological Investigations of Mosaic Disease in the Tomato.**

By B. D. BOLAS.

During the past year an attempt has been made to cover a fairly wide range of investigations with the view to obtaining insight into the fundamental nature of the disease rather than to carry any one investigation to a conclusion. The results given in this report are therefore to be regarded as indicating the relative importance of certain lines of work and not as completed researches.

### **The effect of coloured light on aucuba or yellow mosaic.**

Four experimental chambers were prepared. No. 1 was illuminated by light of wave length 8,000 to 5,800 Angström units. No. 2 was illuminated with light of 4,000 to 5,700 Angström units, while Nos. 3 and 4 were illuminated by white light. The greenhouse in which these chambers were installed formed chamber No. 5. The coloured lights were obtained by the use of specially prepared gelatine colour filters, the light absorption being determined spectroscopically before use,

The radiant energy in all the chambers was determined by a number of observations with a Moll thermopile and galvanometer and was arranged to be approximately equal in chambers 1, 2 and 3 during the bright part of the day. Temperatures were approximately equal in 1, 2, 3 and 4 but were about 10°F. higher in 5.

In order to study the light in the various chambers control plants inoculated with distilled water were placed in each chamber at the same time as the infected plants and from dry weight determinations the mean rate of gain in total dry weight during the period of the experiment was determined. The figure for the "Efficiency Index" or rate of gain in weight was calculated as suggested by Professor V. H. Blackman (*Ann. Bot.*, 1919, 33, 353), and served as a means of comparison between the conditions in the different chambers.

The following results were obtained in one experiment:—

| Chamber.                                 | 1.<br>Red.           | 3.<br>Blue-green.    | 3.<br>White.         | 4.<br>White.         | 5.<br>White.         |
|------------------------------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| Relative total radiation                 | 3                    | 3                    | 3                    | 8                    | 20                   |
| Wave length of Light,<br>A.U.            | 8,000<br>to<br>5,800 | 4,000<br>to<br>5,700 | 4,000<br>to<br>8,000 | 4,000<br>to<br>8,000 | 4,000<br>to<br>8,000 |
| Efficiency index (% per<br>day controls) | 4.2                  | 3.4                  | 3.8                  | 10.7                 | 17.4                 |
| Symptoms after 12 days                   | Slight               | Very slight          | Moderate             | Strong               | Strong               |

These results suggest that at the low light intensities which prevailed during the course of this experiment symptoms are least severe in the case of blue-green light, and also less severe in red light than in white light. It is also interesting to note that the severity of the symptoms increased in white light as the light intensity increased.

The Efficiency Index of the infected plants was determined in a manner similar to that used for the control plants, the only difference being that "t" in the formula, Efficiency

Index =  $\frac{100 (\log_{10} Q_t - \log_{10} Q_i)}{t \log_{10} e}$  was 13 in the infected plants

and 12 in the controls, that is to say that the infected plants were sampled one day after the controls. There is, however, no reason to assume that this fact will affect the value of the comparative results.

The results obtained were as follows:—

| Chamber.                   | 1.<br>Red. | 2.<br>Blue-green. | 3.<br>White. | 4.<br>White. | 5.<br>White. |
|----------------------------|------------|-------------------|--------------|--------------|--------------|
| E.I. Controls ... ..       | 4.2        | 3.4               | 3.8          | 10.7         | 17.4         |
| E.I. Infected ... ..       | 5.5        | 2.0               | 5.4          | 9.1          | 14.8         |
| E.I. Inf.                  |            |                   |              |              |              |
| E.I. Con. $\times 100$ ... | 130        | 59                | 142          | 85           | 85           |



The foregoing experiments were carried out in April. Experiments carried out in May and June, when both the duration of daylight and the mean light intensity were considerably higher, showed less difference between the intensity of symptoms in the different chambers, while in these cases the efficiency index of the infected plants was less than that of the controls. This suggests that the effect of mosaic disease on the efficiency of the plant is most strongly felt in the presence of blue-green light.

In red and in white light the effect on the plant's efficiency is less severe than in blue-green light, the reaction in white light being similar to that in red in low intensities while the harmful effect of the virus on the plant's efficiency increases as the intensity of light goes up.

#### **Fractional adsorption. Ordinary mosaic.**

Experiments were made on the separation of infected tomato sap by a method of fractional adsorption on filter paper. Various slightly different methods were used but the essential principle underlying each was to allow the infected sap to diffuse by capilarity through Whatman's No. 1 filter paper. Inoculations made by friction with the paper torn from the centre of the moist spot so produced gave as a rule less virulent symptoms than corresponding infections made from the edge of the moist spot.

In no case was "stripe" produced in infections from the centre while both "stripe" and "fern-leaf" symptoms were of fairly common occurrence in infections made from the edge.

#### **Inoculation method. Ordinary and aucuba mosaic.**

A modification of the method of F. O. Holmes, who subjected the leaves of the plant to be infected to gentle friction with cheese cloth moistened with the infected sap, was introduced. This method consists in tearing and folding a small portion of clean dry filter paper by means of sterile forceps, moistening the edge of the folded paper with the inoculum and applying the moist edge to the leaf of the plant to be infected with just sufficient friction to produce the slightest mechanical injury. This method is very much quicker than the method of pricking through a drop of the inoculum on the leaf and gives a much higher percentage of infections. Up to the present this method has been used for several hundred inoculations and there has not been a single failure. Control inoculations using distilled water as the inoculum showed practically no permanent injury to the leaf.

Other methods of inoculation with aucuba mosaic were studied, pricking through a drop of infected sap placed on the



leaf to be inoculated, pricking through an infected leaf laid over the leaf to be inoculated, scarification with a roughened glass scarifier moistened with the infected sap, and gentle friction with the infected leaf after cutting or tearing in order to break some of the cells of the infected leaf, moistening if necessary. While no difference in the type of symptom was observed it was found that very gentle friction with filter paper moistened with the infected sap or with an infected leaf gave a very much higher percentage of infection, 100%, than the other methods which gave infections of the order of 85%.

The temperature at which the inoculation is carried out appears to have some effect on the duration of the incubation period, thus in one experiment with *aucuba* mosaic it was found that leaves maintained at 40°C. for fifteen minutes before, during, and after inoculation with an inoculum at the same temperature were not infected, similar inoculations made between 32°C. and 13°C. showed mottle in six days, while inoculations made at 11°C. took eight days, and inoculations made at 5°C. took 13 days to produce mottle.

#### **Movement of virus in electric field. Ordinary mosaic.**

A number of experiments have been made in which the effect of a small electric current of about 0.5 micro-amps. per square centimeter (the voltage gradient being about 1.2 volts per c.m.), passing through a rod of gelatine jelly having a cavity at its mid-point containing infected sap has been studied. Control experiments made with safranine sulphonie acid showed a very marked migration of the coloured ions towards the negative pole. While the results obtained with the infected sap must not be looked upon as being conclusive, indications were obtained that the portion of the virus producing severe symptoms was only to be found in the middle and towards the positive pole while a portion capable of producing mild symptoms was to be found on the negative side of the mid-point. In these experiments no evidence of change in value Ph. or of oxidase content were found within the range of travel of the virus.

#### **Effect of length of day. Ordinary mosaic.**

Experiments were made in which inoculated plants were exposed to an artificially shortened period of daylight while a control group of similarly inoculated plants was exposed to the full day during the latter part of March. Those plants receiving the full day showed normal mottling while those receiving a duration of daylight equal to a December day showed the typical winter symptoms of blistering and slight deformation on a certain proportion of the leaves. This rather suggests that the seasonal variation in length of day may in

part be responsible for the different types of reaction. No attempt was made in these experiments, to reduce the intensity of light or the temperature to winter conditions.

### **Clearing of virus.**

Satisfactory clearing was obtained in some cases by crushing the plants to extract the juice, centrifuging, freezing *in vacuo* at a pressure of about 0.5 m.m. Hg. and drying as ice. On taking up the residue in water and centrifuging an infectious liquid was obtained from infected plants. A distillate obtained *in vacuo* during the drying process was not infectious.

### **"Fern-leaf" or "mottle."**

The conditions determining the type of symptom produced by both ordinary and aucuba mosaic have been studied. In the case of ordinary mosaic it has been found possible to produce fern-leaf symptoms by an artificial shortening of the day at low temperatures while a partial separation of the fern-leaf producing infection has been obtained by fractional adsorption on filter paper, the fern-leaf infection travelling to a greater distance on the filter paper than the mottle infection. This result is in agreement with that obtained by Kraybill and Eckerson, *Am. Jour. Bot.*, October, 1927, who obtained separation of the fern-leaf producing infection by filtration through fritted glass. The findings of these workers that fern-leaf so produced is less infectious than the mottle were also confirmed. Fern-leaf produced by aucuba mosaic has been converted into typical mottle by suitable conditions of light and temperature. thus a plant showing fern-leaf develops typical mottle on exposure for a few days to a temperature of 90°F. and an artificial twelve-hour day having a light intensity of 750 foot candles.

### **Physical properties of the virus.**

A considerable amount of work has been carried out on the physical properties of the mosaic infection such as adsorption, electrophoresis, dialysis, etc., but the results obtained have not been sufficiently consistent to justify any detailed report at this stage.

### **Metabolism. Aucuba mosaic.**

A photosensitive reaction has been observed between infected juice and an aqueous solution of colloidal chlorophyll prepared from fresh healthy tomato plants. The reaction manifests itself by a destruction of the characteristic green colour and the development of a brown colour. The reaction has not been observed to occur to the same extent with a previously boiled sample of infected sap and does not appear to be directly correlated with the oxidase or peroxidase content of the sap. Marked local changes in the starch

distribution have been observed in inoculated leaves, these are often in the following order:—inhibition of starch removal in the dark, formation of a zone in which removal is accelerated, complete removal of, and inhibition of, starch formation in the light. Starch removal from the uninoculated leaves of an artificially infected plant in the dark appears to be accelerated in the early stages of infection, while local absence of starch precedes the appearance of symptoms. Marked accumulation of starch is found in parts of the leaves and complete absence in other parts after symptoms have developed.

The acidity of an aqueous extract of infected leaves sampled at dawn is greater than that of healthy leaves.

These and other results, regeneration of a green colour when the yellow area of the leaf is treated with a copper salt, for example, rather suggest that the mottling may be correlated with a pathological production of acid from the carbohydrate in the leaf.

### **Summary.**

#### **Effect of coloured light on aucuba mosaic.**

This has been studied and evidence has been obtained that when due attention is paid to obtaining equal assimilation rates no marked difference in type of symptoms or duration of incubation period is found in plants grown in long wave, short wave, or white light, provided the intensity and duration of the diurnal light period are above a certain limit.

#### **Methods of inoculation.**

Comparative studies of several methods indicate that very gentle friction of the leaf to be infected with the injured surface of the infected leaf is considerably more effective than many of the more elaborate methods. The temperature at which inoculation is carried out appears to exert some influence on the incubation period.

#### **Effect of environment on type of symptom.**

The conditions determining the type of symptom have been investigated and transformation from "fern-leaf" to "mottle" and "mottle" to "fern-leaf" has been effected.

#### **Physical properties of the virus.**

These investigations have given inconclusive results in most cases.

#### **Metabolism.**

Certain aspects of the carbohydrate metabolism of infected plants have been subjected to a preliminary investigation and marked local and general reactions have been observed in the pre-symptom stage. (See "Nature," September 27th, 1930).

### 3. Entomological Report.

#### 1. Red Spider Mite.

(*Tetranychus telarius* L.)

By E. R. SPEYER.

In previous accounts of the life-history of the Red Spider mite, it has been recorded that the female mite, after hatching from the egg, passes through three stages, separated by two moults, and on moulting the third time reaches maturity, whereas the male mite reaches maturity already after the second moult.

Records, kindly sent by Mr. W. G. Garlick, of Ontario, show that in Canada the life-histories of the two sexes are similar. To check the disparity, female mites in the stage previous to maturity were isolated so that eggs not impregnated by the male could be obtained later. It has been established that such eggs develop exclusively to individuals of the male sex. The unfertilised females were allowed to lay eggs upon cucumber leaves, and the eggs obtained kept at a temperature of 70°F.

Seven individuals after hatching were reared to maturity, and it was found that one stage had been overlooked in previous investigations owing to the short period of time passed in the first nymphal resting stage and the second nymphal active stage, and the similarity in appearance of the first to the second nymphal resting stages.

The average duration of the various stages in the life-history of the male were roughly as follows:—

|                                               |     |     |     |     |     |          |
|-----------------------------------------------|-----|-----|-----|-----|-----|----------|
| Egg Stage                                     | ... | ... | ... | ... | ... | 4 days.  |
| Larval Stage (active period)                  | ... | ... | ... | ... | ... | 1 day.   |
| Larval Stage (resting period)                 | ... | ... | ... | ... | ... | 1 day.   |
| First Nymphal Stage (active period)           | ... | ... | ... | ... | ... | 1 day.   |
| " " " (resting period)                        | ... | ... | ... | ... | ... | 1½ days. |
| Second Nymphal Stage (active period)          | ... | ... | ... | ... | ... | ½ day.   |
| " " " (resting period)                        | ... | ... | ... | ... | ... | 2 days.  |
| Total period from hatching of egg to maturity | ... | ... | ... | ... | ... | 7 days.  |

The number of stages and moults in the life-history of the Red Spider Mite is therefore the same for both sexes.



## 2. Tomato-Moth Caterpillar.

(*Polia oleracea* L.)

By E. R. SPEYER.

The chief method of control of this serious pest of the tomato plant has been the spraying of the plants twice or three times before the first-truss fruit has begun to swell, with a suspension of lead arsenate in water.

Owing to the poisonous nature of lead arsenate, later spraying, when the plants are in bearing, is impossible. During recent years, various metallic fluorides and silico-fluorides have been used in the United States of America as stomach poisons for caterpillars and other biting insects, and a number of these have now been tested with a view to obtaining a substitute for lead arsenate in tomato plant spraying. These compounds, if poisonous at all, are very much less so than arsenicals.

Fluorides, such as sodium fluoride, aluminium fluoride, and calcium fluoride (fluor-spar) are poisonous to the tomato moth caterpillar in proportion to their solubility in water, and those which are soluble cause severe scorching of the foliage if used at dilutions sufficiently strong to kill the caterpillars. Of the silico-fluorides tested, the sodium compound is injurious to foliage, while the barium compound is not injurious, but is practically without effect upon the caterpillars.

Aluminium silico-fluoride was poisonous to the caterpillar and appeared to have no injurious effect upon the foliage, but the price of this compound is high.

The most satisfactory results were obtained with a double fluoride of sodium and aluminium which exists in nature as a mineral called cryolite. This substance is only very slightly soluble in water, and is not injurious to the foliage of tomato plants. Its action upon the caterpillar in the form of a powder when dusted upon plants or when used in suspension in water is considerable, but its crystalline nature makes distribution upon foliage a matter of difficulty.

Lately, samples of synthetic cryolite in the form of a very fine powder of a more-or-less non-crystalline structure have been obtained, and a good measure of success has attended its use in the control of a serious outbreak of caterpillar, using 6 lbs. of synthetic cryolite to 100 gallons of water to which 2 ozs. saponin was added as a spreader. The action of the sample of cryolite was uncertain upon some caterpillars which were fed upon young plants after spraying, and a few consumed a large amount of well-sprayed foliage, and continued

to live for many days without any increase of growth. It remains to be determined if the action of cryolite upon the caterpillars may not largely be one of contact.

### 3. Thrips as a Pest of Roses.

By E. R. SPEYER.

Very serious losses have been sustained upon a nursery through injury to Rose-blooms by Thrips over a number of consecutive years. The injury is entirely due to the *Thrips fuscipennis*, Hal.

The habits of *Thrips fuscipennis*, Hal., differ from those of the lighter coloured *Thrips tabaci*, Lind, a common pest of Cucumber foliage and Carnation blooms. The eggs of *Thrips fuscipennis* are laid within the tissues of the outer flower petals, either shortly before or at the time that the buds begin to open. The chief injury, however, is not connected with the egg-laying habit, but is due to the feeding of the adults at the tip of the young bud; when the flower opens later the tips of the petals are of a dark brown colour and may be badly deformed so that the blooms are unmarketable. The larvæ do not appear to cause injury when feeding between the petals of the unopened bud, but in this situation they can not be reached easily with sprays or with fumigants.

The larva changes to the prepupal stage and the latter to the pupal stage usually upon the inner side of a calyx sepal, and does not descend to the ground as is the case with *Thrips tabaci*.

The foliage of the Rose is rarely injured, but in the absence of buds, eggs may be laid within the opening leaves of weak shoots early in spring. Whereas *Thrips tabaci* has been found to pass the winter in rose flowers under glass, the hibernating quarters of *Thrips fuscipennis* have not been determined.

*Thrips tabaci* is probably entirely parthenogenetic in English glasshouses, while males of *Thrips fuscipennis* have been obtained in large numbers except during the winter months.

It is probable that the control of Thrips upon Roses and Carnations lies in the early removal and immediate burning of buds or flowers which contain the insects. These are readily recognised by their deformed tips in the former, and by the discoloured petals in the latter case.



#### 4. Red Spider Mite Control.

By W. H. READ.

Many tests have been made in order to find a substitute for the petroleum oil emulsion sprays used in controlling the Red Spider Mite on account of the serious damage occasionally caused to tomato plants by *œdema* resulting from the use of such emulsions.

The most promising of the substances tested up to the present is a sulphonated derivative of crude petroleum oil which yields a complete control of the Mite at a dilution of from 1 in 250 to 1 in 300. As this substance was not obtained until the end of the year additional tests will be necessary to ascertain whether it will produce *œdema* when applied at various stages of growth.

It may be of interest to observe that the sulphonated product is a viscous liquid which yields stable emulsions when stirred into the water in the spray tank and the spray fluid possesses definite wetting properties. No direct injury, *i.e.*, burning or scorching of the foliage or flowers, results from applying the insecticide to tomato plants at a concentration of 1 in 100, whilst dilution with hard water is without appreciable effect on the stability of the resulting emulsion.

Experiments have shown that *œdema* following the application of emulsified oil sprays is connected with a reduced rate of transpiration since it was found that of the water taken up by the roots during a period of five days after a single spraying with a 1 in 80 dilution of a standard petroleum emulsion, the proportion of water transpired was 90·6 % whilst in the case of unsprayed plants under identical conditions of temperature, light and humidity, the water transpired was 98·0% of that taken up by the roots.

It has been suggested that spraying with glue solutions might serve to control the Mite and tests have shown that whilst practically all the "active" Mites are killed by spraying with a 2% glue solution the eggs and many of the resting stages survive. The application of glue at this strength causes leaves which touch to adhere to one another and also makes the fruit sticky.

Experiments are in progress to determine the effect of repeated applications of both glue and the sulphonated petroleum derivative to plants from the seedling stage until maturity and under varying conditions of temperature, etc.

#### Fumigation experiments.

A large number of volatile substances have been tried as fumigants for the control of the Red Spider Mite and in

addition the systematic investigation of series of compounds, commenced at the end of last year, has been continued. The results obtained from experiments with the aliphatic alcohols, their formates and the methyl esters of some of the fatty acids, may be briefly summarised as follows:—

The toxicity of the normal aliphatic alcohols increases as the series is ascended to a maximum not yet determined, whilst the toxicity of their formates appears to reach a maximum at normal butyl formate and then declines. Methyl formate is a notable exception, however, as it is more than twice as active as normal butyl formate.

The normal compounds in all the series are more toxic than their isomers, the toxicity decreasing with increased branching of the chain and this decrease is greatest when the branching is at the alpha position to the hydroxyl or carboxyl group. Thus, whilst there is no discernable difference in the toxicities of the normal and iso amyl alcohols these are both more than twice as toxic to the Mite as is tertiary amyl alcohol. Those differences are even more pronounced in the formates.

Although the toxicity of many of the members of the series of compounds tend to increase with increased boiling point there is no correlation between the activities of the members of a homologous series and their vapour pressures at the temperature at which the fumigations were conducted. Methyl formate, which has a boiling point of about 107°F., was the most volatile of the substances tested and yet the most active towards the Mite. A large number of tests were made to find if conditions could be obtained under which methyl formate could be used without injury to plants, but it was impossible to obtain control of the Mite without causing very severe injury to plants.

It is to be regretted that in general the substances which have the greatest effect on the Mite cause the most severe injury to plants.

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## 4. Chemical Investigations.

### 1. Soil Analysis, etc.

About the usual number of samples of soil and water have been submitted for examination. Several samples of turf were found to be sour and in two cases composts made up for propagating were found to be in the same condition. This points to the desirability of the addition of adequate quantities of lime when the composts are being made up.

A sample of ash offered to a grower was found on examination to have a manurial value so low that the cost of cartage alone would have made its use uneconomic.

Several samples of shoddy contained between 12% and 14% of total nitrogen.

Damage done to young cucumber plants and suspected as being due to bone meal caused several samples to be examined. In no case was the presence of any of the usual plant poisons detected and in no case did young cucumber plants at the Station show injury when the samples were added to the potting soil.

An interesting case of the effect of salt in the water supply merits mention. Samples of water from two wells on a certain nursery contained .281 and .234 grams of sodium chloride per litre respectively. It was not considered that these amounts were in themselves particularly harmful unless the soil should retain the salt when the water was used. An analysis of the soil in question showed that considerable retention of salt was taking place since the sodium chloride content amounted to no less than 0.269%. That this concentration was not a uniform one or that it was merely fugitive is indicated by the fact that a sample of soil from the same nursery taken later in the same season showed a much lower salt content. Attention has already been drawn in earlier reports to the desirability of using water supplies reasonably free from salt.

### 2. The composition of the soils in some of the experimental plots.

When some of the manurial experiments in Houses 3 and 4 were discontinued at the end of the 1928 season samples from the plots were reserved for analysis. Some of the data likely to prove of interest are presented in Tables 1 and 2,

Table 1.

Mechanical Analysis of Plots—House 4.

| Plot Treatment.                   | Coarse Sand. | Fine Sand. | Silt. | Clay. | Loss on Solution. |
|-----------------------------------|--------------|------------|-------|-------|-------------------|
| Double Complete Artificials ...   | 24.22        | 35.33      | 16.58 | 13.05 | 5.20              |
| Unmanured ... ..                  | 23.85        | 37.20      | 13.78 | 13.23 | 3.26              |
| Standard and Complete Artificials | 21.64        | 33.75      | 12.92 | 15.48 | 6.81              |
| Complete Artificials and Dung ... | 22.92        | 35.84      | 12.90 | 14.95 | 5.18              |
| Complete Artificials ... ..       | 24.01        | 37.51      | 10.93 | 13.53 | 5.50              |
| No Phosphates ... ..              | 25.23        | 38.92      | 13.90 | 14.58 | 3.99              |
| No Nitrogen ... ..                | 23.97        | 38.92      | 10.14 | 14.48 | 4.43              |
| No Potash ... ..                  | 22.54        | 36.92      | 15.28 | 14.90 | 4.56              |

It will be seen from Table 1 that sand accounts for about 60% of the soil. The values for the clay are higher than those given for this soil in earlier reports. This is due to the fact that these last analyses were carried out by the method recommended by the Agricultural Educational Association, and this involves preliminary treatment of the soil sample with hydrogen peroxide. This tends to break down aggregates of clay particles and consequently the "clay fraction" actually determined tends to be higher than that found by the older methods.

The values given in the column headed "Loss on Solution" give some indication of the manurial treatment. As was to be expected the unmanured plot shows a comparatively low value, highest values occurring where no nutrient has been omitted. The chemical data in Table 2 offer rather more information.

The values for the loss on ignition in the first four plots are considerably higher than in the second four. This can be accounted for, partly at all events, by the fact that for some seasons straw manure was added as part of the standard treatment for Plots 1 and 2, and Plots 3 and 4 have received straw manure for some years.

Two facts emerge from the values for total nitrogen. The first is that straw manure increases the nitrogen content and that the omission of any one nutrient (Plots 6, 7, 8) is accompanied by a fall in nitrogen content as compared with that found when complete artificials are applied.

The lime and the carbonate values for Plot 8 are of interest. It will be seen that these values are the lowest in the series and occur where potash has been omitted. The value for total phosphoric acid in this plot is also low. Data for the analyses of foliage from these plots have suggested that where potash is withheld from the soil the plants take more than the "normal" amount of phosphates. The present

**Table 2.**  
Chemical Analysis of Plots—House 4.

| Plot.                       | Treatment.            |                     | Loss on Ignition. | Total Nitrogen. | Iron Oxide and Alumina. | Lime. | Magnesia. | Total Potash. | Total Phosphoric Acid. | Available Potash. | Available Phosphoric Acid. | Total Carbonates as CaCO <sub>3</sub> . |
|-----------------------------|-----------------------|---------------------|-------------------|-----------------|-------------------------|-------|-----------|---------------|------------------------|-------------------|----------------------------|-----------------------------------------|
| 1                           | Double Complete       | Artificial...       | ...               | ...             | ...                     | 4.32  | 0.264     | 0.705         | 0.596                  | 0.083             | 0.072                      | 3.02                                    |
| 2                           | Unmanured             | ... ..              | ...               | ...             | ...                     | 4.27  | 0.265     | 0.434         | 0.421                  | 0.035             | 0.070                      | 3.42                                    |
| 3                           | Standard and Complete | Artificial          | ...               | ...             | ...                     | 5.79  | 0.301     | 0.669         | 0.431                  | 0.131             | 0.121                      | 4.93                                    |
| 4                           | Complete              | Artificial and Dung | ...               | ...             | ...                     | 4.31  | 0.414     | 0.753         | 0.694                  | 0.125             | 0.125                      | 4.55                                    |
| 5                           | Complete              | Artificial          | ...               | ...             | ...                     | 3.62  | 0.201     | 0.564         | 0.462                  | 0.099             | 0.059                      | 3.00                                    |
| 6                           | No Phosphates...      | ...                 | ...               | ...             | ...                     | 3.29  | 0.185     | 0.544         | 0.308                  | 0.090             | 0.112                      | 3.45                                    |
| 7                           | No Nitrogen           | ...                 | ...               | ...             | ...                     | 3.18  | 0.229     | 0.540         | 0.282                  | 0.094             | 0.101                      | 3.73                                    |
| 8 <sub>x</sub> <sup>✓</sup> | No Potash             | ...                 | ...               | ...             | ...                     | 2.13  | 0.247     | 0.525         | 0.288                  | 0.054             | 0.102                      | 2.56                                    |

figures would appear to support the view that such phosphates enter the plant accompanied by substances other than potash and that lime is intimately concerned in the process.

Regarding the values for total potash and phosphoric acid it appears that these are definitely increased by the addition of stable manure.

The omission of nitrogen as well as of potash has reduced the total phosphoric acid content.

The values for the available potash and phosphoric acid do not call for much comment except that in the plots from which nitrogen and potash have been withheld respectively the proportion of phosphoric acid which is available appears to be high.

Similar analyses were made on samples from the plots in House 3. In this case the outstanding features of the data are firstly that graded additions of potash appear to have little effect on the potash determined after fusion, and secondly that the additions are accompanied by increases in the exchangeable potash.

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## 5. Temperature Investigations.

### 1. General Observations.

By O. B. ORCHARD and W. F. BEWLEY.

The investigations on the temperatures of the air and soil of glasshouses, commenced in 1929, have been continued throughout the current year. Comparative results have been obtained from the two types of houses, of which particulars are given in the Annual Report for 1929, page 69. These houses were House No. 1 of the ordinary vinery or low-gutter type, and House No. 7 which is of the aeroplane or high-gutter type.

These investigations have been conducted on the lines of those of the previous year in an attempt to confirm the results then obtained.

Temperatures were recorded daily at 9.30 a.m. in the same manner as described for last year, and the mean weekly temperatures calculated. A comparison of the results obtained in 1930 with those previously obtained (Annual Report, 1929, page 71) confirms that

- (1) The soil in the centre of House No. 1 (vinery type) is 3°–4°F. warmer than that 3 ft. from the east side, and 2°F. warmer than that on the west side.
- (2) The soil 3 ft. from the east side of the houses, which in both cases is an outside wall, is approximately 2°–3°F. cooler than that 3 ft. from the west side of the same house.
- (3) The soil temperature of House No. 7 (aeroplane type) was 2°–3°F. warmer than No. 1 (vinery type) during the early months of the year. The soil temperature of both houses became the same early in July.
- (4) The difference between the soil temperature at the ends of the houses was much less pronounced in 1930 than in 1929. Possibly this was due mainly to the absence of particularly strong winds from the S.E.

It is interesting to note that the maximum soil temperature in 1929 was 68°F. and occurred on July 2nd, and that during 1930 the maximum soil temperature was also 68·8°F., but did not occur until August 30th, on which day the maximum outside soil temperature of 73°F. at a depth of 1 ft. was registered.

In view of the mild weather conditions experienced during the propagating season of 1930, and the lateness of the tomato fruit in maturing at the commencement of the picking season, the following graphs are given. It is thought that they may afford a comparison of the temperatures prevailing in an ordinarily ventilated glasshouse during the years 1929 and 1930.

Fig. No. 1 shows the number of hours of sunshine per week recorded at this Station for the two years.

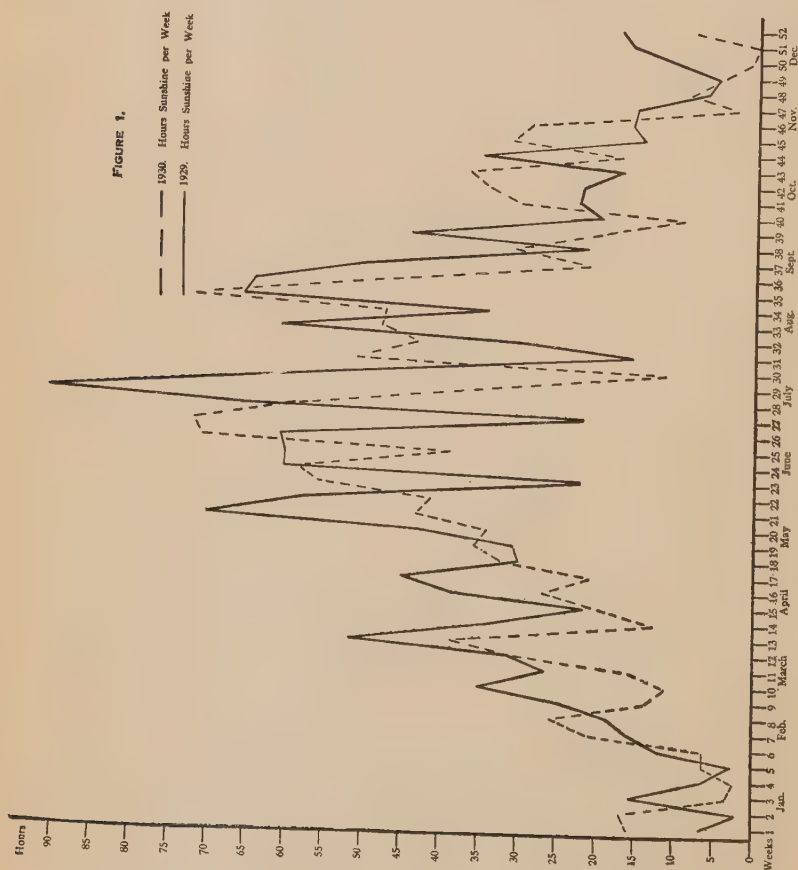


Fig. No. 2 shows the soil temperature of House No. 1 at a depth of 6 ins., and the outside soil temperature at a depth of 1 ft., commencing the second week in February each year.

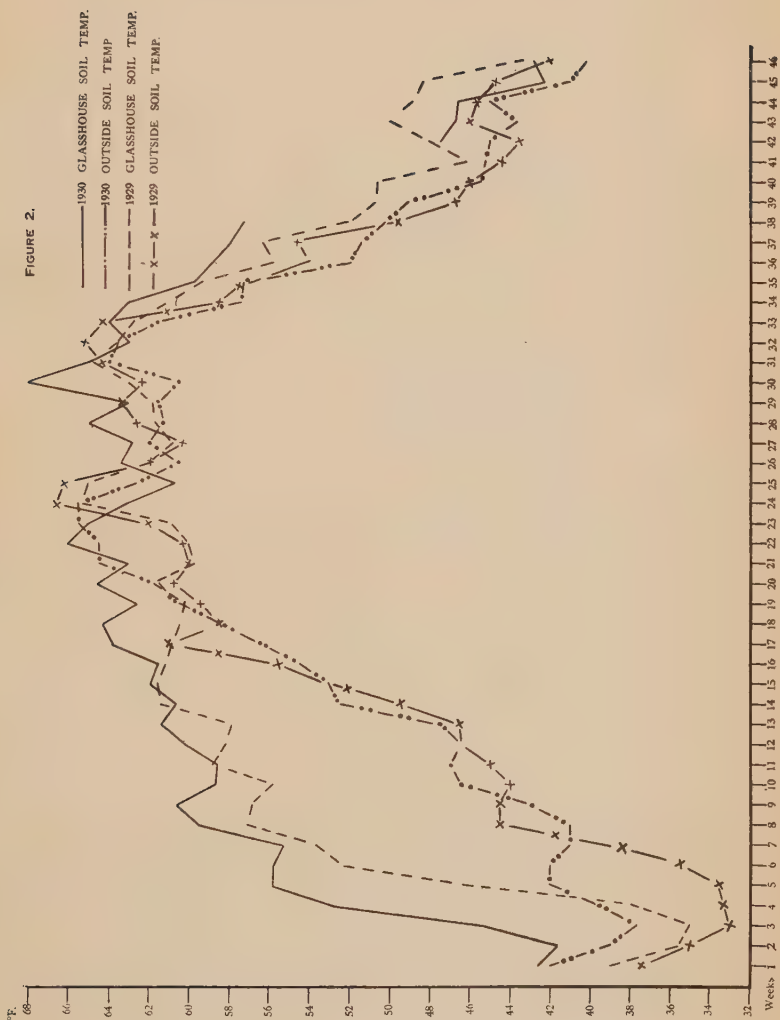


Fig. No. 3 shows the weekly mean air temperature of House No. 1, commencing the third week in March, together with the mean outside air temperature recorded in the meteorological screen.

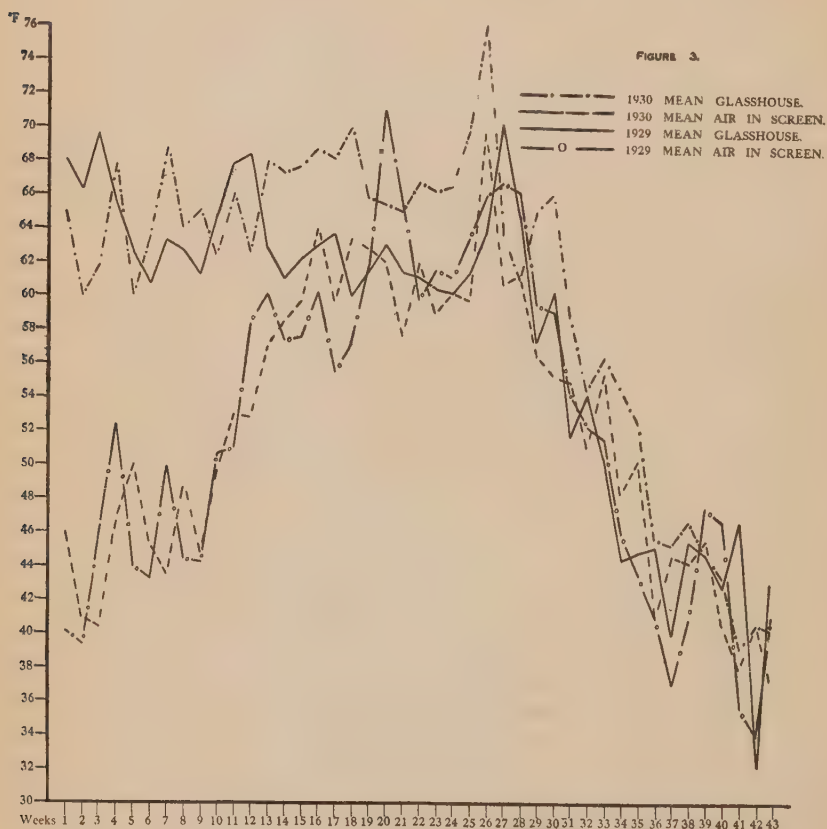
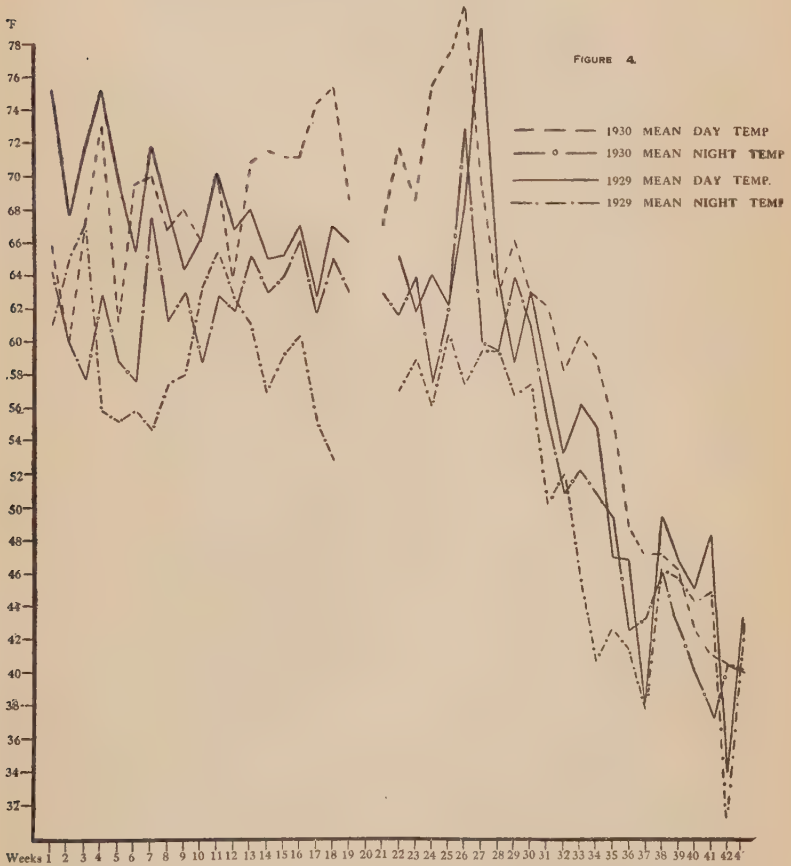


Fig. No. 4 shows the weekly mean day and mean night air temperatures recorded in House No. 1, commencing the second week in March.

It will be observed from Fig. No. 1 that the number of hours of sunshine per week until the end of June was greater in 1929 than in 1930. Figs. Nos. 2, 3 and 4 show respectively that during the early months of 1930 the soil temperatures, the mean air temperatures and the mean night air temperatures of the glasshouses under observation were considerably above those of 1929. These records show that with regard to the

production of early tomato fruit, sunshine is of greater importance than temperature conditions, since the rather higher air and soil temperatures during the past year have not compensated for the lower light intensities.



## 2. Soil and Air Temperatures.

By O. B. ORCHARD and W. F. BEWLEY.

The experiments begun during 1928, in House 6, to ascertain the best air temperature for the tomato crop, were continued with a slight variation during the current year, the soil of Chambers Nos. 2, 5 and 6 being heated by means of buried electric resistance cables.

Chamber No. 1 was used for a carbon dioxide experiment. The rest of the chambers were thermostatically controlled to maintain a minimum air temperature of 65°F. in Nos. 2 and 3, 60°F. in Nos. 4 and 5, and 55°F. in No. 6. The thermostatic controls of the heating system in these chambers are accurate to plus or minus 2°-3°F., but some difficulty was experienced in maintaining chamber No. 5 at an even temperature of 55°F. owing to the mildness of the season.

Electric current was automatically applied by time switch between the hours of 10 p.m. and 6 a.m. each night, from the 26th February until 10th May.

Fifty-six plants of the variety E.S. 1 were planted in each chamber on 27th February, fire heat having been applied two weeks previously. As shown in the Thirteenth Annual Report (1927) the "maturation period" of the tomato is from eight to nine weeks. It seems obvious therefore that the effect of heating the soil would continue for eight or nine weeks after the heating was discontinued, and in the accompanying Table, the weight of fruit obtained from each chamber is tabulated until the end of July to allow for this period.

| Chamb.<br>No. | Air<br>Temp. | Average<br>Vari-<br>ation. | Mean<br>Soil<br>Temp. | May.<br>Lbs.<br>per<br>Plant. | June.<br>Lbs.<br>per<br>Plant. | July.<br>Lbs.<br>per<br>Plant. | Total<br>Lbs. per<br>plant to<br>end July. | Tons<br>per<br>Acre. |
|---------------|--------------|----------------------------|-----------------------|-------------------------------|--------------------------------|--------------------------------|--------------------------------------------|----------------------|
| 2             | 65           | +2.5                       | 69.1                  | 0.61                          | 2.48                           | 0.65                           | 3.74                                       | 28.42                |
| 3             | 65           | +1.1                       | 64.6                  | 0.58                          | 1.64                           | 0.59                           | 2.81                                       | 21.35                |
| 4             | 60           | +4.0                       | 62.6                  | 0.13                          | 1.87                           | 0.94                           | 2.94                                       | 22.34                |
| 5             | 60           | +3.8                       | 68.1                  | 0.27                          | 1.91                           | 0.91                           | 3.09                                       | 23.48                |
| 6             | 55           | +5.2                       | 65.7                  | 0.01                          | 1.87                           | 1.03                           | 2.91                                       | 22.11                |

As in previous experiments at this Station with electrically heated soils, the fruit was found to mature much more rapidly than on the control plots.

The soil temperatures given in the above Table are the mean soil temperatures for the ten weeks during which the soil was heated, calculated from the mean weekly readings.

It has been previously shown that under the conditions of light, etc., prevailing in these chambers, the optimum temperature for the tomato is 62°F.—63°F. From the results obtained from this year's experiments it would appear that higher air temperatures might be employed with advantage providing the soil temperature is also raised. It is hoped to be able to obtain more information during the coming season.



## 6. Miscellaneous Investigations.

### 1. Ripening of Tomato Fruit by Treatment with Ethylene.

By W. H. READ.

In view of the large amount of conflicting data regarding the effect of atmospheres containing traces of ethylene in hastening the ripening of tomatoes, investigations have been commenced with the object of deciding whether this treatment is likely to become of commercial importance.

For this purpose an almost airtight metal chamber of about 8 cubic feet capacity has been adapted by fitting an electrical heating system which enables constant temperatures to be maintained. The ethylene was obtained from a cylinder of the compressed gas fitted with the latest British type of pressure reducing valve and regulator which can be adjusted to give, within limits, any desired rate of flow of the gas; the rate of flow being obtained by means of a special gauge calibrated in cubic feet per minute.

The concentration of ethylene employed in the tests was in nearly all cases 1 in 10,000 since this is generally regarded as the optimum. Although it has not been possible to determine the best concentration experimentally, it has been found that there was no advantage in using higher concentrations than the above. The optimum temperature for the production of firm fruit was found to be in the region of 80°F. Temperatures exceeding this, whilst slightly hastening the colouring of the fruit, rendered it soft. It was also found that a high humidity (about 70%) with ventilation of the chamber and "re-gassing" every twenty-four hours was of advantage.

A brief summary of the findings of these preliminary experiments is as follows:—

Individual fruits of the same variety and as near as could be judged of the same state of maturity showed considerable differences in the time taken to attain the desired ripeness when treated with ethylene.

At periods when conditions are favourable for rapid ripening of fruit on the plants, fruit picked when fully swelled and about to change colour did not ripen appreciably earlier when treated with ethylene than the control fruits left on the plants.

Under these conditions the treated fruit ripened from two to four days earlier than a similar sample picked from the plants and maintained under the same temperature and humidity conditions as the ethylene treated fruit.

Quite green, fully swelled fruit turned yellow in the course of one to four days but the time taken to change from this to a normal red was such that there was no advantage over leaving the fruit on the plants.

The treated fruit was indiscernable in appearance from the normal fruit and there was little or no difference in flavour and texture.

At the end of the season a portion of the fruit treated with ethylene ripened from one to three days earlier than similar fruit on the plants but in some cases as much as 50% of that treated took from two to five days longer.

Great difficulty was experienced in picking samples of green fruit at the same stage of maturity and it is apparent that a slight hastening of ripening may be obtained when the fruit is at the stage where growth is complete but the colour has not begun to change.

## **2. The use of Electric Light in the Propagation Houses.**

By W. F. BEWLEY and B. D. BOLAS.

The production of early tomatoes has occupied the minds of growers for many years, and with the present economic situation it has become still more important. Successful early production necessitates a supply of strong, hardy plants with the bottom trusses well developed by late January or early February. This means that young plants must be raised during the period between November and January.

Usually tomato seedlings grown at this time of the year are extremely poor. The foliage is weak and pale, the stems spindly and roots develop very slowly, the plants showing every symptom of light deficiency which is so obvious at such times. Naturally the possibility of using artificial light has occurred to many, but experiments have proved singularly unfruitful. The ordinary gas-filled electric bulbs can be used to supply additional light, but unfortunately they radiate such a large percentage of heat that seedling plants exposed to them tend to be drawn and develop unduly soft growth.

The following experiments were devised to discover the most suitable source of light and method of use.

A number of electric lamps with reflectors were set up in a greenhouse, each lamp being 2 feet above the bench. Each batch of plants consisted of seedling tomato plants in pots, twenty in baked and twenty in virgin soil, together with a box of forty-eight seedlings with cotyledons just expanded. Light intensity due to the lamps was determined by means of a Holophane Lumeter and total radiation was determined in most cases by means of a Moll thermopile and galvanometer. The following experiments were set up and in a number of cases a "Figure of Merit" showing the ratio of light to heat was calculated as follows:—

$$\text{Figure of Merit} = \frac{\text{Light intensity in foot candles.}}{\text{Micro amperes from Moll thermopile exposed under lamp.}} \times 10$$

Approximate day and night temperatures were noted at intervals during the experiment.

| Series. | Light Source.                         | Reflector.      | Light in Foot Candles due to Lamps. | Day T'mp. °F. | Night T'mp. °F. | "Figure of Merit." | Type of Plant produced.                              |
|---------|---------------------------------------|-----------------|-------------------------------------|---------------|-----------------|--------------------|------------------------------------------------------|
| 1       | 500 watt Gas-filled lamp.             | Enamelled iron. | 200                                 | 65            | 55              | 14.5               | Good colour, dark stems                              |
| 2       | 500 watt Gas-filled lamp.             | Essex Board.    | 250                                 | 68            | 55              | 13.1               | Tall, pale green colour, soft.                       |
| 3       | With fan.                             | Essex Board.    | 250                                 | 65            | 44              | 13.0               | Tall, pale green colour, soft.                       |
| 4       | With fan.                             | Enamelled iron. | 203                                 | 65            | 55              | 14.4               | Better type than 2 and 3, not so good as 1.          |
| 5       | 500 watt Gas-filled "day-light" lamp. | Enamelled iron. | 130                                 | 65            | 55              | —                  | Good colour, dark stems, growth slower than 1.       |
| 6       | 200 watt "Sun-ray" lamp.              | Enamelled iron. | 55                                  | 60            | 55              | 7.5                | Good colour, softer than 1 and 5, and growth slower. |
| 7       | Control, day-light only.              | —               | —                                   | 60            | 55              | —                  | Growth very slow.                                    |

These measurements suggest that the use of an enclosed reflector system of Essex Board is less satisfactory from the point of view of the light-heat ratio than the use of the ordinary enamelled iron reflector. There appears to be little reduction in temperature by the use of a fan under the conditions of these experiments in which the air-speed over the plants was maintained at about 1.5 feet per second.

The lamps were switched on at 9 a.m. and off at 9 p.m. so that the light of the lamps was used in addition to that of daylight while the duration of the diurnal light period was increased by their use. The experiments were commenced on January 9th, and the use of the lamps was discontinued on February 2nd. The ventilators of the house were kept open and the heat shut off during the time the lamps were burning.

The plants showed marked differences, their fitness for planting being roughly in the same orders as the "figure of merit." The experiment showed considerable variation in the type of growth obtained under the different conditions. The plants in No. 1 Series were very good, and suggested that with further investigation the method of utilising electric light may become a commercial possibility. In Series 2 and 3 heat was in excess, and the plants were too soft and drawn to be of any use. In Series 4, the heat being reduced, growth was more satisfactory, but not so good as in No. 1. Light intensity was reduced in Series 5 and 6 and, in consequence, growth was slower. The plants exposed to ordinary lighting conditions made extremely slow growth and were about five weeks behind those in Series 1.

Experiments carried out in February on the artificial "hardening" of plants with short wave light were unsatisfactory while some preliminary work with a special lamp appeared promising, but a detailed report on these two experiments does not appear to be justifiable at this stage.

### **3. A Device for the Study of Soil Ventilation.**

By B. D. BOLAS.

The study of cucumber root rot has invariably shown that it attains the most serious proportions when the beds are wet and "tight"; the injury has accordingly been attributed to "imperfect aeration." Actually this term is used somewhat loosely, and it has become necessary to investigate the whole problem.

As a preliminary an attempt has been made to obtain accurate measurements of the rate at which air passes through such beds under known conditions.

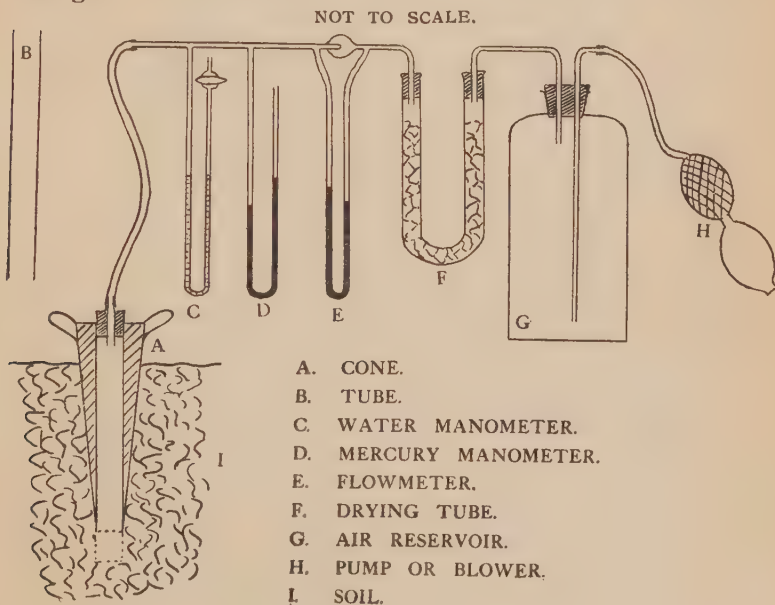
Past work on the nature of the soil in relation to aeration has shown that a number of physical constants of the soil such as water holding capacity, size of particles, pore space, etc., are of considerable importance, but the determination of these has usually involved the removal of the soil from its original

position, and its exposure to a number of extraneous influences such as mechanical disturbance, partial drying, etc., by which its condition may be considerably altered.

The apparatus described in this paper has been devised with the view to obtaining measurements of air flow through the bed with a minimum of disturbance to the soil, and highly satisfactory preliminary results have been obtained.

The method consists of the determination of the pressure required to produce a flow of air at a definite rate, one litre per minute, from a cylindrical cavity one inch in length and one inch in diameter, within the bed and at a prearranged depth below the surface, usually one foot. Such a flow of air passes through the bed and ultimately reaches the surface, so that the resistance offered by the bed may be taken as an index of the degree of ventilation.

The apparatus consists of a solid metal cone two feet in length, and slightly over one inch in diameter at its lower end. The diameter of the upper end is two and a half inches. Axially through the cone passes a hole one inch in diameter in which slides a piece of steel tubing fitting the hole and three feet in length. To the upper end of the cone are fixed two strong handles by which it can be forced into the soil under examination. The cone and tube are shown by A and B in the figure.





In use the tube is first forced into the bed to the pre-arranged depth with a twisting motion so that a column of soil enters the tube, the cone is then fitted over the tube which still remains in the bed and forced down with a twisting motion until its end is one inch from the bottom of the tube which is then withdrawn carrying with it a cylindrical column of soil and leaving a cylindrical cavity of one inch length and one inch diameter within the bed at the lower end of the cone. The cone is not removed from the bed during the measurement. A rubber stopper carrying a flexible rubber tube connected to a "flowmeter," and manometer is inserted in the upper end of the axial hole in the cone and air is forced through the bed by means of a small rubber hand bellows or blower until the rate of flow remains stationary at one litre per minute as indicated by the flowmeter. While this rate of flow is maintained the pressure is read off either on the water manometer C in the figure in the case of a well ventilated bed or on the mercury manometer D in the case of a badly ventilated bed. If the mercury manometer is used the reading is multiplied by 13.6 to make it comparable with the reading of the water manometer. The stopcock connected to the water manometer must be closed before using the apparatus for badly ventilated soils.

No evidence of any leakage of air round the cone has been found in any ordinary soil, and if certain precautions are taken, chiefly that of passing the air over lumps of pumice moistened with concentrated sulphuric acid to remove water vapour and dust which might obstruct the jet of the flowmeter, remarkably consistent results have been obtained. One charge of pumice and acid should be sufficient for many hundreds of measurements and a complete measurement can be made in a few minutes. It has been found desirable to fit an air reservoir of about one litre capacity between the blower and the flowmeter to obtain a uniform flow of air.

While it is not claimed that this form of the apparatus represents finality, exceedingly interesting results have been obtained with it, thus the resistance of an ordinary loose garden soil was found to be equivalent to about 5 millimetres of water at six inches depth, that of a well steamed cucumber bed about 6 millimetres of water while that of an old unsteamed cucumber bed showed the astonishing resistance of the equivalent of 1,200 millimetres of water.

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## Manurial Treatment in the Tomato Experiments.

### (1) Lime.

All Houses except parts of Nos. 11 and 12 received ground caustic lime at the rate of 2 tons per acre.

### (2) Stable Manure.

Houses 2, 5 and 6 received 30 tons and Houses 7 to 10 received 15 tons of stable manure per acre.

### (3) Base-dressing.

Houses Nos. 2 and 5 received  $\frac{3}{4}$ -lb. per sq. yd. of the following mixture:—

- 1 part bone meal.
- 1 part bone flour.
- 1 part ground hoof and horn.
- 1 part sulphate of potash.

Houses Nos. 6, 7, 8, 9, 11 and 12 received the following per sq. yd.:—

- $\frac{1}{4}$ -lb. bone meal.
- $\frac{1}{4}$ -lb. bone flour.
- $\frac{1}{4}$ -lb. sulphate of potash.

### (4) Top-dressing.

Houses Nos. 2, 5, 6, 7, 8, 9, 11, and 12 received 2 ozs. per sq. yd. of the following mixture every 14 days at discretion:—

- 3 parts sulphate of ammonia.
- 2 parts dried blood.
- 7 parts 30% superphosphate.
- 5 parts pure dissolved bones.
- $\frac{1}{2}$  part bone flour.
- $2\frac{1}{2}$  parts sulphate of potash.

This gave 5 % ammonia, 24 % total phosphates, 12 % soluble phosphates, and 7 % potash on examination.



APPENDIX C.  
**Dates of Cultural Operations during 1929—1930.**

| Crop.         | Sown.           | Potted into<br>60's. | Potted into<br>32's. | Planted<br>out in<br>borders. | First<br>Mulching. | First Top<br>Dressing. | First<br>Fruit<br>Picked. | Last Fruit<br>Picked. |
|---------------|-----------------|----------------------|----------------------|-------------------------------|--------------------|------------------------|---------------------------|-----------------------|
| Cucumbers ... | Dec. 12<br>1929 | Dec. 17<br>1929      | Jan. 10<br>1930      | Feb. 6<br>1930                | April 1<br>1930    | Mar. 22<br>1930        | Mar. 14<br>1930           | Sept. 19<br>1930      |
| Tomatoes ...  | Dec. 14<br>1929 | Jan. 10<br>1930      | —                    | Feb. 27<br>1930               | —                  | May 2<br>1930          | May 19<br>1930            | Oct. 10<br>1930       |

| 1930.     | Air Temperatures |      |               |              | Grass Temp.   |          |                     | Rainfall    |               |                   | Mean Soil Temperatures |          | Hygrometer          |                     |           |                                  | Bright Sunshine |       | Baro-<br>meter |        |
|-----------|------------------|------|---------------|--------------|---------------|----------|---------------------|-------------|---------------|-------------------|------------------------|----------|---------------------|---------------------|-----------|----------------------------------|-----------------|-------|----------------|--------|
|           | Mean             |      | Absolute Max. |              | Absolute Min. | Av. Min. | Total Precipitation | No. of Days | Greatest Fall | Soil Temperatures |                        | Dry Bulb | Depres. of Wet Bulb | Relative Humidity % | Dew Point | Total Daily No. of Aver-<br>Hrs. | Ins.            |       |                |        |
|           | Max.             | Min. | Date          | Temp.        |               |          |                     |             |               |                   |                        |          |                     |                     |           |                                  |                 | Date  |                | 1 ft   |
|           | °F.              | °F.  | °F.           | °F.          | °F.           | °F.      | Ins.                | Ins.        | Ins.          | °F.               | °F.                    | °F.      | °F.                 | °F.                 | °F.       | °F.                              | °F.             |       |                |        |
|           | °F.              | °F.  | °F.           | °F.          | °F.           | °F.      | Ins.                | Ins.        | Ins.          | °F.               | °F.                    | °F.      | °F.                 | °F.                 | °F.       | °F.                              | °F.             |       |                |        |
| January   | 46               | 36.4 | 59            | 19th         | 29            | 5th      | 26                  | 2.61        | 18            | .43               | 4th                    | 42.3     | 43.2                | 42.5                | 1.03      | 91.4                             | 39.5            | 32.6  | 1.0            | 29.242 |
| February  | 44.2             | 33.7 | 53            | 27th         | 28.5          | 8th      | 27                  | 0.67        | 10            | .18               | 1st                    | 36       | 41                  | 36                  | 1.4       | 81.0                             | 35.8            | 61.7  | 2.2            | 29.994 |
| March     | 48               | 35.7 | 60            | 26th         | 24            | 19th     | 21                  | 1.61        | 13            | .58               | 15th                   | 42       | 42.6                | 43                  | 2.0       | 83.0                             | 39.5            | 102.9 | 3.3            | 30.430 |
| April     | 56               | 38.2 | 69            | 25th         | 26            | 19th     | 23                  | 2.41        | 18            | .48               | 3rd                    | 48.6     | 46.6                | 48                  | 1.8       | 86.0                             | 45              | 114.3 | 3.71           | 29.661 |
| May       | 58               | 43.2 | 73            | 29th         | 34            | 18th     | 32.5                | 2.75        | 21            | .52               | 31st                   | 54.9     | 54                  | 50.2                | 2.1       | 83.2                             | 49              | 159.8 | 5.1            | 29.888 |
| June      | 70               | 48.2 | 83            | 30th         | 39            | 9th      | 40                  | 2.04        | 7             | 1.45              | 18th                   | 62.8     | 61                  | 65.2                | 3.2       | 74                               | 51              | 249.9 | 8.3            | 29.932 |
| July      | 69               | 46.7 | 82.5          | 6th          | 35            | 4th      | 35                  | 1.87        | 17            | .35               | 20th                   | 63.5     | 61.8                | 64.0                | 4.0       | 79.5                             | 54.2            | 183.8 | 5.92           | 29.253 |
| August    | 74               | 51.8 | 93            | 29th         | 42            | 19th     | 40                  | 2.36        | 19            | .45               | 21st                   | 62       | 60.2                | 66.6                | 3.6       | 79.6                             | 61.2            | 227.0 | 7.32           | 29.870 |
| September | 66.2             | 51.2 | 81            | 5th          | 40            | 15th     | 39                  | 2.99        | 17            | .58               | 13th                   | 59.5     | 59.8                | 58.9                | 2.2       | 89.2                             | 57.2            | 131.3 | 4.37           | 29.519 |
| October   | 60               | 43.2 | 68            | 16th<br>17th | 28            | 26th     | 27                  | 1.26        | 19            | .24               | 23rd                   | 51.0     | 53.2                | 53                  | 2.2       | 85.5                             | 48.3            | 123.7 | 3.99           | 29.770 |
| November  | 52               | 35.7 | 63            | 10th         | 20            | 16th     | 19                  | 4.06        | 20            | .58               | 1st                    | 44.4     | 48.6                | 44                  | 1.01      | 92.0                             | 41.2            | 70.4  | 2.34           | 29.860 |
| December  | 43.8             | 33.6 | 52            | 27th<br>28th | 25.5          | 21st     | 26                  | 2.57        | 17            | .44               | 30th                   | 41.7     | 43.6                | 38.3                | 0.48      | 96.0                             | 37.7            | 20.0  | 0.64           | 29.867 |

Total rain for year, 27.2 ins.

No. of days precipitation, 196.

Total bright sunshine for year, 1477.4 hours.

DIAGRAM SHOWING ARRANGEMENT OF EXPERIMENTAL PLOTS, 1930.

